Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

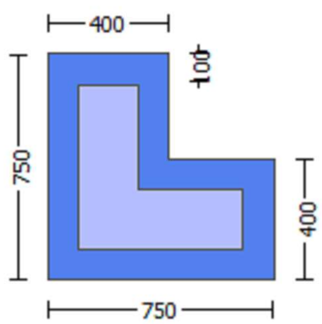
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

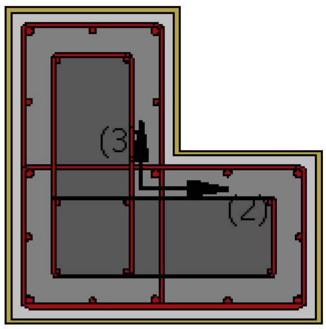
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -1.5690E+007
Shear Force, Va = -5209.785
EDGE -B-
Bending Moment, Mb = 56787.791
Shear Force, Vb = 5209.785
BOTH EDGES
Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 558275.125

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 620305.695
VCol = 620305.695
knl = 1.00
displacement_ductility_demand = 0.02232182

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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.5690E+007
Vu = 5209.785
d = 0.8*h = 600.00
Nu = 16800.923
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 55439.87 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 70773.799 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 6.3679592E-005
θy = (My*Ls/3)/Eleff = 0.0028528 ((4.29),Biskinis Phd))
   My = 4.1179E+008
   Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3011.65
   From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.4491E+014
      factor = 0.30
         Ag = 440000.00
         Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
         N = 16800.923
      Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
  with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
     d = 707.00
     ξy = 0.19345095
     A = 0.01018613
     B = 0.00449653
      with pt = 0.00214476
           pc = 0.00416509
           pv = 0.00378591
           N = 16800.923
           b = 750.00
           δ'' = 0.06082037
Φy_comp = 1.6463045E-005
 with fc* (12.3, (ACI 440)) = 33.48734
      fc = 33.00
      fl = 0.49678681
      b = bmax = 750.00
      h = hmax = 750.00
      Ag = 0.44
         ρg = pt + pc + pv = 0.01009575
         rc = 40.00
         Ae/Ac = 0.31291181
         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 = 0.19180888
     A = 0.01002479
     B = 0.00440616
      with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

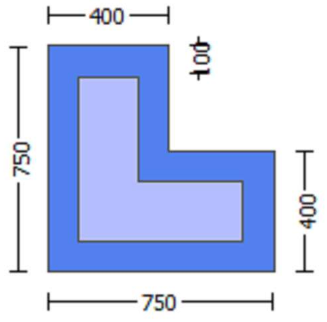
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

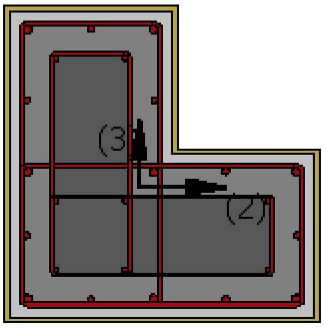
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647

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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252

εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-

Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00

hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542

εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579

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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -200080.825

Shear Force, V2 = -5209.785
Shear Force, V3 = 97.60185
Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00174766
θu = θy + θp = 0.00194184

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00194184 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2049.97
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681

b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- 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 = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 16800.923
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

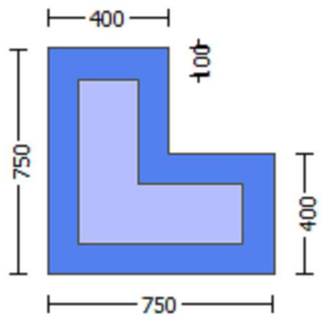
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

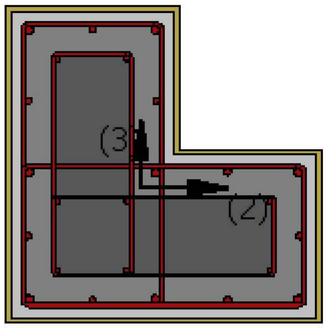
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -200080.825
Shear Force, Va = 97.60185
EDGE -B-
Bending Moment, Mb = -91261.79
Shear Force, Vb = -97.60185
BOTH EDGES
Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 579817.926
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 644242.14

VCol = 644242.14
knl = 1.00
displacement_ductility_demand = 0.01284134

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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.41662
Mu = 200080.825
Vu = 97.60185
d = 0.8*h = 600.00
Nu = 16800.923
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 55439.87 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 70773.799 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.4935843E-005
θy = (My*Ls/3)/EIeff = 0.00194184 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2049.97
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739

lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

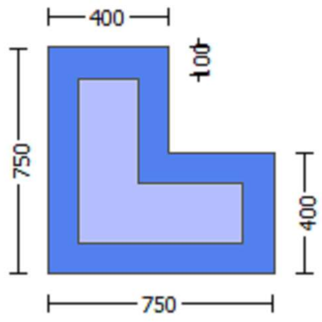
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

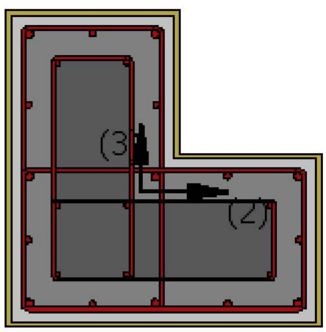
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062

ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866

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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441

BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252

$\varepsilon sh2$ = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
$\varepsilon su2$ = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and $\varepsilon y2$,$\varepsilon sh2$,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
$\varepsilon y1$,$\varepsilon sh1$,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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
$\varepsilon y1$,$\varepsilon sh1$,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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008

---

with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -1.5690E+007
Shear Force, V2 = -5209.785

Shear Force, V3 = 97.60185
Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00256752
θu = θy + θp = 0.0028528

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0028528 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3011.65
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00

h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- 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 = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 16800.923
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032

pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

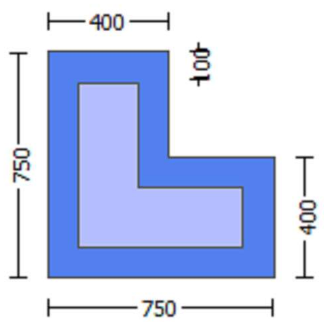
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

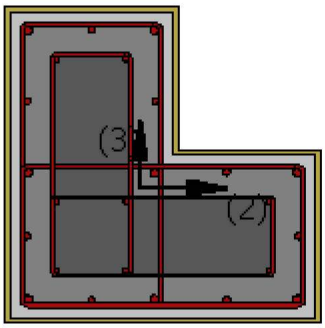
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -1.5690E+007
Shear Force, Va = -5209.785
EDGE -B-
Bending Moment, Mb = 56787.791
Shear Force, Vb = 5209.785
BOTH EDGES
Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 684441.513
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 760490.57
VCol = 760490.57

knl = 1.00
displacement_ductility_demand = 0.05755874

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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 56787.791
Vu = 5209.785
d = 0.8*h = 600.00
Nu = 16800.923
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 55439.87 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 70773.799 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 736127.561
bw = 400.00

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.6356814E-005
θy = (My*Ls/3)/EIeff = 0.00028418 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00

ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

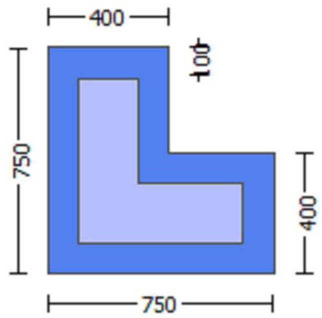
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

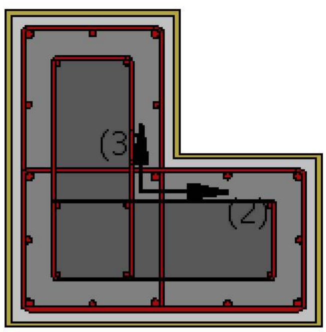
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252

εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097

fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866

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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES

Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062

ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00

n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -91261.79
Shear Force, V2 = 5209.785
Shear Force, V3 = -97.60185

Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00079715
θu = θy + θp = 0.00088572

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00088572 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 935.0416
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00

Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- 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 = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 16800.923
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575

b = 750.00
d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

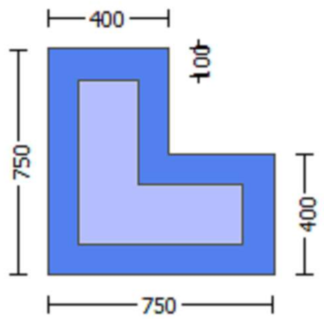
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

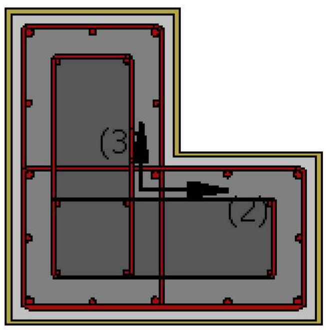
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -200080.825
Shear Force, Va = 97.60185
EDGE -B-
Bending Moment, Mb = -91261.79
Shear Force, Vb = -97.60185
BOTH EDGES
Axial Force, F = -16800.923
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 684441.513
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 760490.57
VCol = 760490.57
knl = 1.00

displacement_ductility_demand = 3.3964651E-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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 91261.79
Vu = 97.60185
d = 0.8*h = 600.00
Nu = 16800.923
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 55439.87 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 70773.799 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 3.0083216E-008
θy = (My*Ls/3)/EIeff = 0.00088572 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 935.0416
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463

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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

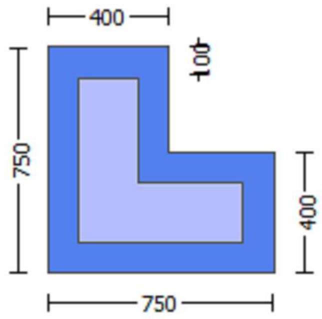
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

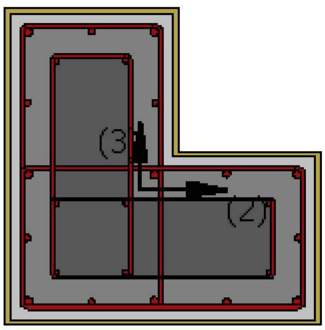
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90

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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062

ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00

n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747

εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00

effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997

fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = 56787.791
Shear Force, V2 = 5209.785
Shear Force, V3 = -97.60185
Axial Force, F = -16800.923

Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00025576
θu = θy + θp = 0.00028418

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00028418 ((4.29),Biskinis Phd))
My = 4.1179E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 16800.923
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0742160E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19345095
A = 0.01018613
B = 0.00449653
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 16800.923
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6463045E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44

ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19180888
A = 0.01002479
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19276987 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- 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 = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 16800.923
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00

d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

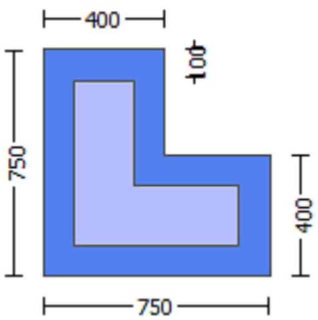
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

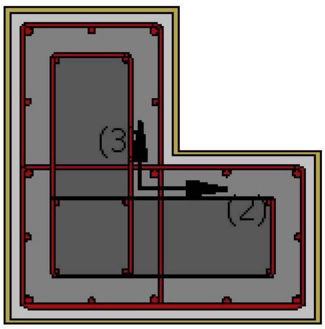
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -2.3777E+007
Shear Force, Va = -7895.088
EDGE -B-
Bending Moment, Mb = 86052.109
Shear Force, Vb = 7895.088
BOTH EDGES
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 558299.293
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 620332.548
VCol = 620332.548
knl = 1.00
displacement_ductility_demand = 0.03382628

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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 2.3777E+007
Vu = 7895.088
d = 0.8*h = 600.00
Nu = 17072.715
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 55439.87 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 70773.799 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 9.6518553E-005
θy = (My*Ls/3)/Eleff = 0.00285336 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3011.649
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

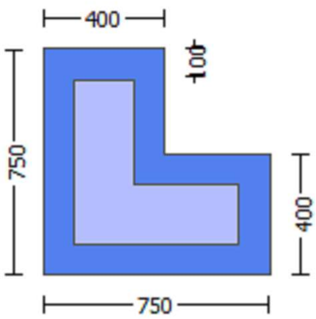
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

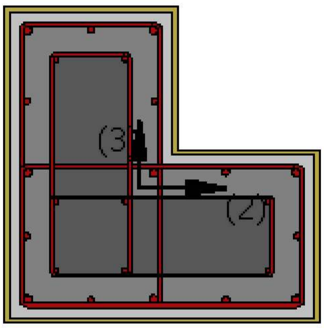
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759

Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997

fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008

---

with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991

lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331

$\varepsilon su2 = 0.00542681$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and $\varepsilon y2, \varepsilon sh2$,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
$\varepsilon yv = 0.0014252$
$\varepsilon shv = 0.00456062$
ftv = 453.2097
fyv = 377.6747
$\varepsilon suv = 0.00542681$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and $\varepsilon yv, \varepsilon shv$,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
$\varphi u = \varphi su$ (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
$\lambda = 1$
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
$\psi t = 1.00$
$\psi s = 0.80$
$\psi e = 1.00$
cb = 25.00

Ktr = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -303215.468
Shear Force, V2 = -7895.088
Shear Force, V3 = 147.9095
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03240089
θu = θy + θp = 0.03600099

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00194226 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2050.007
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575

rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- Calculation of θp -

From table 10-8: θp = 0.03405873
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 17072.715
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00

f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

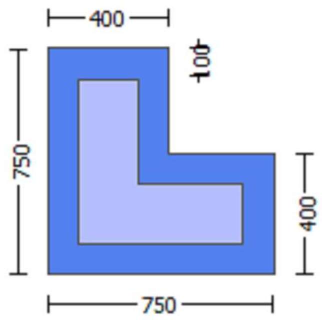
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

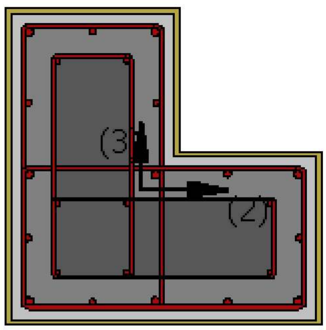
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -303215.468
Shear Force, Va = 147.9095
EDGE -B-
Bending Moment, Mb = -138295.202
Shear Force, Vb = -147.9095
BOTH EDGES
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 579843.527
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 644270.586
VCol = 644270.586
knl = 1.00
displacement_ductility_demand = 0.01946439

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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.41668
Mu = 303215.468
Vu = 147.9095
d = 0.8*h = 600.00
Nu = 17072.715
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 55439.87 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 70773.799 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

- Calculation of θ/θy for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation θ = 3.7804926E-005
θy = (My*Ls/3)/EIeff = 0.00194226 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2050.007
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

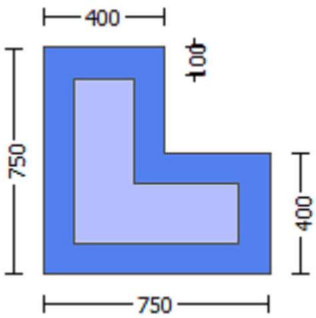
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

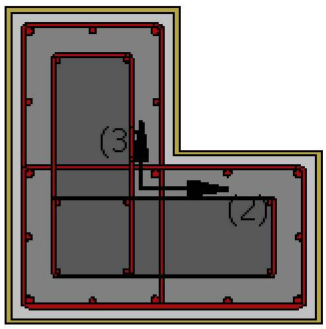
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331

εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Aslt = 0.00

-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00

ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647

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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

---

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -2.3777E+007
Shear Force, V2 = -7895.088
Shear Force, V3 = 147.9095
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00

-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03322088
θu = θy + θp = 0.03691209

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00285336 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3011.649
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00

Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- Calculation of θp -

From table 10-8: θp = 0.03405873
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 17072.715
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

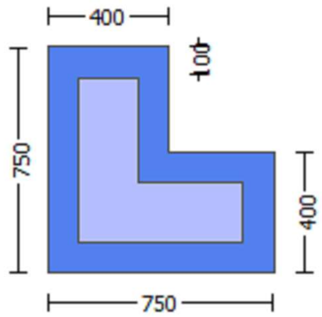
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

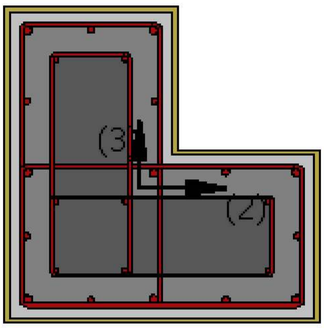
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -2.3777E+007
Shear Force, Va = -7895.088
EDGE -B-
Bending Moment, Mb = 86052.109
Shear Force, Vb = 7895.088
BOTH EDGES
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 684489.848
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 760544.275
VCol = 760544.275
knl = 1.00
displacement_ductility_demand = 0.08726657

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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 86052.109
Vu = 7895.088
d = 0.8*h = 600.00
Nu = 17072.715
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 55439.87 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 70773.799 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.4803980E-005
θy = (My*Ls/3)/EIeff = 0.00028423 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

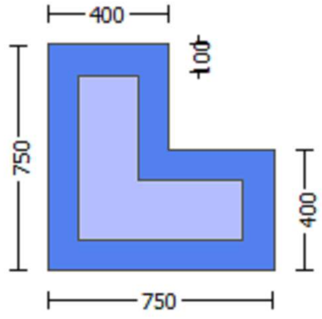
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

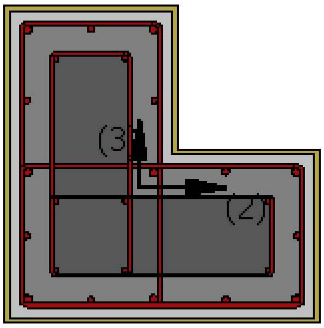
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371

with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647

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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252

εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

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

φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274

Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579

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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -138295.202
Shear Force, V2 = 7895.088
Shear Force, V3 = -147.9095
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274

Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03145013
θu = θy + θp = 0.03494459

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00088586 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 934.9988
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181

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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- Calculation of θp -

From table 10-8: θp = 0.03405873
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 17072.715
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

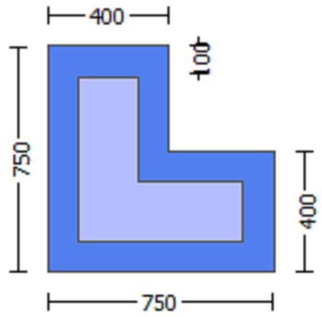
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

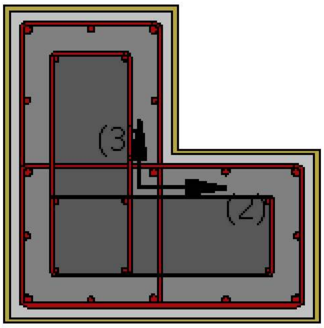
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = -303215.468
Shear Force, Va = 147.9095
EDGE -B-
Bending Moment, Mb = -138295.202
Shear Force, Vb = -147.9095
BOTH EDGES
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 684489.848
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 760544.275
VCol = 760544.275
knl = 1.00
displacement_ductility_demand = 3.3077552E-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 = 21.31818, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 138295.202
Vu = 147.9095
d = 0.8*h = 600.00
Nu = 17072.715
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 126213.67
where:
Vs,jacket = Vs,j1 + Vs,j2 = 55439.87
Vs,j1 = 55439.87 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 70773.799
Vs,c1 = 70773.799 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 400.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 736127.561
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.9301958E-008
θy = (My*Ls/3)/EIeff = 0.00088586 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 934.9988
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

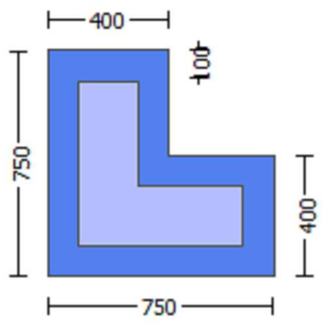
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

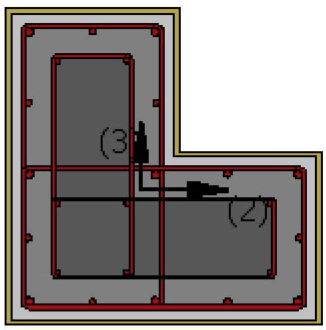
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with

Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062

ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006

Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895

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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77537
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.77482
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 61600.349 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.60
s/d = 0.85
Vs,j2 = 0.00 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.00
s/d = 1.59375
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 78636.768 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.5625
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

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

Constant Properties

Knowledge Factor, κ = 0.90
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03889
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 = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478

Calculation of Shear Capacity ratio , Ve/Vr = 0.81868759
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 535097.371
with
Mpr1 = Max(Mu1+ , Mu1-) = 8.0265E+008
Mu1+ = 4.8921E+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- = 8.0265E+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-) = 8.0265E+008
Mu2+ = 4.8921E+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- = 8.0265E+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 = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252

εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 8.9479397E-006
Mu = 4.8921E+008
----
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 449.345
fy1 = 374.4542
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 374.4542
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 455.1997
fy2 = 379.3331
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.02433675
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.04787748
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04332854
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0276252
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05434683
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.04918322
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.14216778
Mu = MRc (4.14) = 4.8921E+008
φu = φsu (4.1) = 8.9479397E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.7291088E-006
Mu = 8.0265E+008
----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.616
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01186911
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01186911
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.04377629
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

ωfy = 0.04286225
Expression ((15B.6), TBDY) is modified as af = 1 - (Unconfined area)/(total area)
af = 0.31984848
with Unconfined area = ((bmax-2R)^2+(hmax-2R)^2)/3 = 140733.333
bmax = 750.00
hmax = 750.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 870.5244

R = 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 = 0.11512199
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.11081094
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 353600.00 is the 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 = 71100.00 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 = 158733.333 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) = 0.12134906
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 171264.00 is the 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 = 54741.00 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 = 106242.667 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) = 0.87336895
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 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along Y) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along Y) = 1468.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 0.87336895
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.000721
Lstir1 (Length of stirrups along X) = 2060.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082
Lstir2 (Length of stirrups along X) = 1468.00
Astir2 (stirrups area) = 50.26548

Asec = 440000.00
s1 = 510.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0014252
εsh1 = 0.00456062
ft1 = 455.1997
fy1 = 379.3331
εsu1 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 379.3331
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0014252
εsh2 = 0.00456062
ft2 = 449.345
fy2 = 374.4542
εsu2 = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30798991
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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 = 374.4542
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0014252
εshv = 0.00456062
ftv = 453.2097
fyv = 377.6747
εsuv = 0.00542681
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30798991
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 377.6747
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.08977028
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0456314
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.08124101
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 34.2833
εcc (5A.5, TBDY) = 0.00238888
λc = confinement factor = 1.03889
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.11029209
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.05606291
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.099813
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.2110448
Mu = MRc (4.14) = 8.0265E+008
φu = φsu (4.1) = 9.7291088E-006

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.30798991
lb = 300.00
ld = 974.0579
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653603.866

Calculation of Shear Strength at edge 1, Vr1 = 653603.866
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78089
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606

bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 653603.866
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653603.866
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 = 27.68182, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 11.78144
Vu = 0.00051441
d = 0.8*h = 600.00
Nu = 16273.616
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 140237.117
where:
Vs,jacket = Vs,j1 + Vs,j2 = 61600.349
Vs,j1 = 0.00 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j1 is multiplied by αCol,j1 = 0.00
s/d = 1.59375
Vs,j2 = 61600.349 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 510.00
Vs,j2 is multiplied by αCol,j2 = 0.60
s/d = 0.85
Vs,core = Vs,c1 + Vs,c2 = 78636.768
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 78636.768 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 444.44
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.56818182
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 <= 838832.606
bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjlcs

Constant Properties

Knowledge Factor, κ = 0.90
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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 = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
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 = 86052.109
Shear Force, V2 = 7895.088
Shear Force, V3 = -147.9095
Axial Force, F = -17072.715
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 1746.726
-Middle: Asl,mid,jacket = 1545.664
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 461.8141
-Middle: Asl,mid,core = 461.8141
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03090867
θu = θy + θp = 0.03434296

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00028423 ((4.29),Biskinis Phd))
My = 4.1188E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.4491E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182
N = 17072.715
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+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 = 750.00
web width, bw = 400.00
flange thickness, t = 400.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.0743398E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 350.6021
d = 707.00
ξy = 0.19348343
A = 0.01018759
B = 0.004498
with pt = 0.00376294
pc = 0.00416509
pv = 0.00378591
N = 17072.715
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6462519E-005
with fc* (12.3, (ACI 440)) = 33.48734
fc = 33.00
fl = 0.49678681
b = bmax = 750.00
h = hmax = 750.00
Ag = 0.44
ρg = pt + pc + pv = 0.01009575
rc = 40.00
Ae/Ac = 0.31291181
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 = 0.19181501
A = 0.01002364
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19279145 < t/d

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.38498739
lb = 300.00
ld = 779.2463
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 = 27.68182, 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 = 0.8418647
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) = 510.00
n = 24.00

- Calculation of θp -

From table 10-8: θp = 0.03405873
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.81868759
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00376294
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.000721
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 510.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00067082
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 250.00
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 = 17072.715
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 27.68182
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) = 502.0032
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 27.68182

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3
Integration Section: (b)
