Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

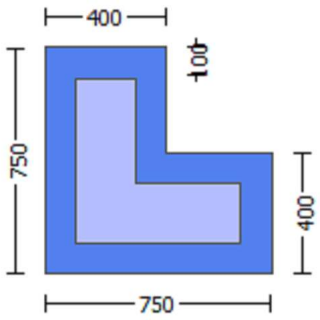
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

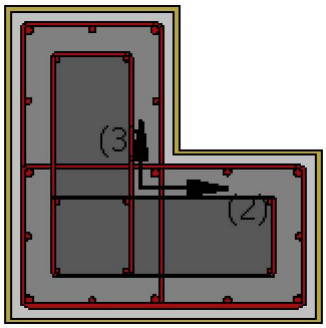
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.8810E+007
Shear Force, Va = -6058.142
EDGE -B-
Bending Moment, Mb = 629358.106
Shear Force, Vb = 6058.142
BOTH EDGES
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 949014.707

Vn ((10.3), ASCE 41-17) = knl*VCol0 = 949014.707
VCol = 949014.707
knl = 1.00
displacement_ductility_demand = 0.01509048

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.8810E+007
Vu = 6058.142
d = 0.8*h = 600.00
Nu = 18615.215
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559
where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 251327.412 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 471238.898 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 88467.249 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 <= 797164.595
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 = 6.6493790E-005
θy = (My*Ls/3)/EIeff = 0.00440634 ((4.29),Biskinis Phd))
My = 6.5012E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3104.908
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

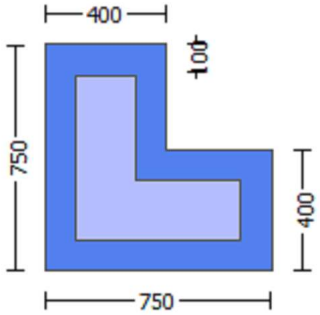
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

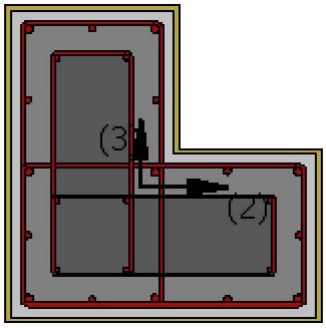
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025

εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025

εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607

Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752

Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34

fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---

with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45

fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34

fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = -399066.903
Shear Force, V2 = -6058.142
Shear Force, V3 = 163.9376
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00609608
θu = θy + θp = 0.00609608

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00345459 ((4.29),Biskinis Phd))
My = 6.5012E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2434.26
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981

A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00264149
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18615.215
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

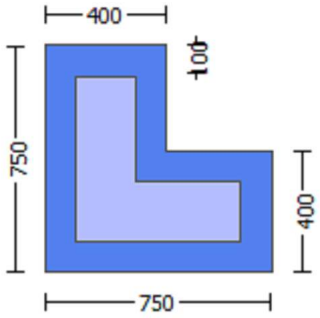
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

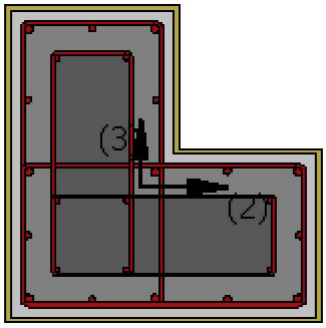
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##########
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

Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -399066.903
Shear Force, Va = 163.9376
EDGE -B-
Bending Moment, Mb = -90444.323
Shear Force, Vb = -163.9376
BOTH EDGES
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 949014.707
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 949014.707
VCol = 949014.707
knl = 1.00
displacement_ductility_demand = 0.0073234

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 399066.903
Vu = 163.9376
d = 0.8*h = 600.00
Nu = 18615.215
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559
where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00

Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 251327.412 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 88467.249 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 = 500.00
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 <= 797164.595
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 = 2.5299333E-005
θy = (My*Ls/3)/EIeff = 0.00345459 ((4.29),Biskinis Phd))
My = 6.5012E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2434.26
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

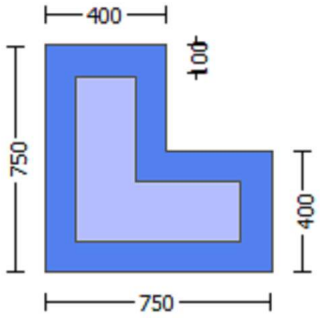
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

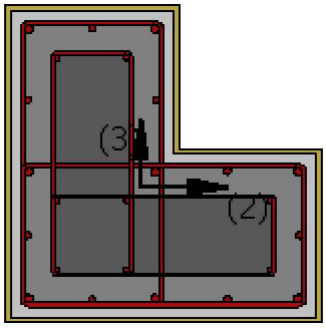
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
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
Secondary Member
Ribbed Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009

---

with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00

s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00

Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:

Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609

where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = -1.8810E+007
Shear Force, V2 = -6058.142
Shear Force, V3 = 163.9376
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00704783
θu = θy + θp = 0.00704783

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00440634 ((4.29),Biskinis Phd))
My = 6.5012E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3104.908
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00264149
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1

shear control ratio VyE/VCol0E = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18615.215
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

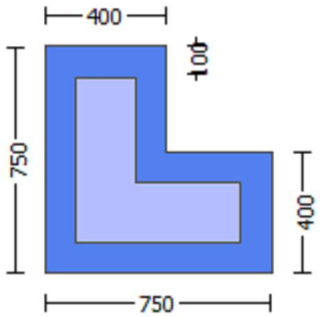
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

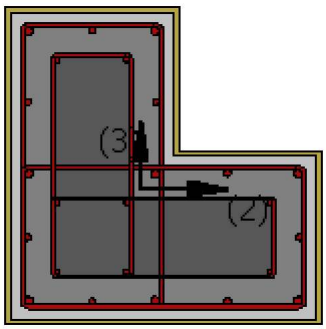
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##########
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.8810E+007
Shear Force, Va = -6058.142
EDGE -B-
Bending Moment, Mb = 629358.106
Shear Force, Vb = 6058.142
BOTH EDGES
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 1.1009E+006
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 1.1009E+006
VCol = 1.1009E+006
knl = 1.00
displacement_ductility_demand = 0.04639374

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 629358.106
Vu = 6058.142
d = 0.8*h = 600.00
Nu = 18615.215
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559
where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 251327.412 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 471238.898 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965

fy = 500.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 88467.249 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 <= 797164.595
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 = 1.9751951E-005
θy = (My*Ls/3)/EIeff = 0.00042575 ((4.29),Biskinis Phd))
My = 6.5012E+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 = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00214476
pc = 0.00416509

pv = 0.00378591
N = 18615.215
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

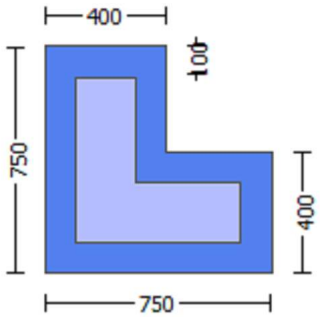
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

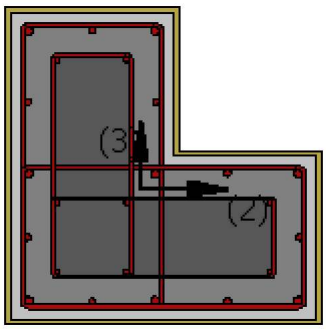
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 1.0898E+006
  knl = 1 (zero step-static loading)

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

  λ = 1 (normal-weight concrete)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 4.00
    Mu = 1518.01
    Vu = 0.00017144
   d = 0.8*h = 600.00
   Nu = 16273.607
   Ag = 300000.00
   From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
   where:
  Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
   Vs,j1 = 523602.964 is calculated for section web jacket, with:
     d = 600.00
     Av = 157079.633
     fy = 555.56
     s = 100.00
   Vs,j1 is multiplied by αCol,j1 = 1.00
     s/d = 0.16666667
   Vs,j2 = 279254.914 is calculated for section flange jacket, with:
     d = 320.00
     Av = 157079.633
     fy = 555.56
     s = 100.00
   Vs,j2 is multiplied by αCol,j2 = 1.00
     s/d = 0.3125
  Vs,core = Vs,c1 + Vs,c2 = 98297.73
   Vs,c1 = 98297.73 is calculated for section web core, with:
     d = 440.00
     Av = 100530.965
     fy = 555.56
     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 = 555.56

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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607

fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45

εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009

φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607

fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00

Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56

s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = -90444.323
Shear Force, V2 = 6058.142
Shear Force, V3 = -163.9376
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00342444
θu = θy + θp = 0.00342444

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00078295 ((4.29),Biskinis Phd))
My = 6.5012E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 551.6996
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00264149
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18615.215
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

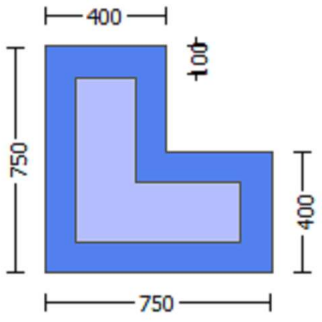
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

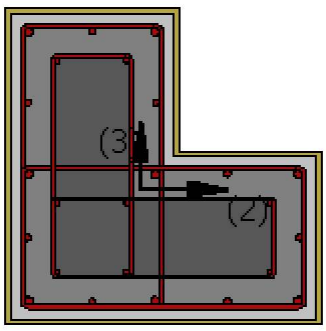
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -399066.903
Shear Force, Va = 163.9376
EDGE -B-
Bending Moment, Mb = -90444.323
Shear Force, Vb = -163.9376
BOTH EDGES
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 1.1009E+006
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 1.1009E+006
VCol = 1.1009E+006
knl = 1.00
displacement_ductility_demand = 1.0335237E-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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 90444.323
Vu = 163.9376
d = 0.8*h = 600.00
Nu = 18615.215
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559
where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 251327.412 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 88467.249 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 = 500.00
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 <= 797164.595
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 = 8.0919355E-009
θy = (My*Ls/3)/EIeff = 0.00078295 ((4.29),Biskinis Phd))
My = 6.5012E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 551.6996
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616

with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

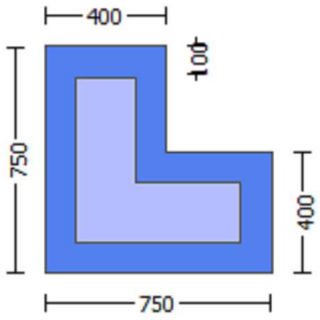
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

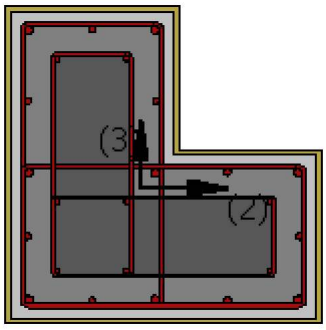
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment

direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34

fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009

---

with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3

MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

```
      characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
      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 = 694.45
        with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
   εy2 = 0.0025
   εsh2 = 0.008
   ft2 = 833.34
   fy2 = 694.45
   εsu2 = 0.032
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/lb,min = 1.00
      εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esu2_nominal = 0.08,
      For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
      characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
      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 = 694.45
        with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
   εyv = 0.0025
   εshv = 0.008
   ftv = 833.34
   fyv = 694.45
   εsuv = 0.032
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/ld = 1.00
      εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esuv_nominal = 0.08,
      considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
      For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
      characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
      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 = 694.45
        with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
-----------------------------------------------------------------------------
-----------------------------------------------------------------------------
```


Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = 629358.106
Shear Force, V2 = 6058.142
Shear Force, V3 = -163.9376
Axial Force, F = -18615.215
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.00306724
θu = θy + θp = 0.00306724

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00042575 ((4.29),Biskinis Phd))
My = 6.5012E+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 = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18615.215
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8677145E-006
with fy = 555.56
d = 707.00
ξy = 0.19284589
A = 0.01015895
B = 0.00446935
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18615.215
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6459533E-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 = 0.19184981
A = 0.01001713
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19284589 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00264149
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18615.215
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

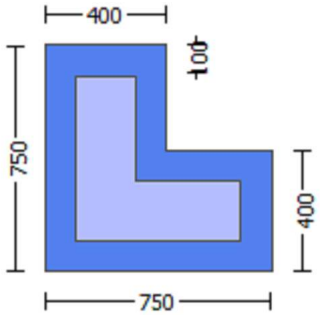
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

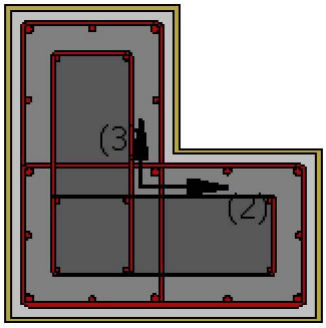
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##########

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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.5109E+007
Shear Force, Va = -4866.131
EDGE -B-
Bending Moment, Mb = 505225.544
Shear Force, Vb = 4866.131
BOTH EDGES
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 948969.187
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 948969.187
VCol = 948969.187
knl = 1.00
displacement_ductility_demand = 0.0121236

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.5109E+007
Vu = 4866.131
d = 0.8*h = 600.00
Nu = 18154.476
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559

where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 251327.412 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 471238.898 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 88467.249 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 <= 797164.595
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 = 5.3408269E-005
θy = (My*Ls/3)/EIeff = 0.00440532 ((4.29),Biskinis Phd))
My = 6.4998E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3104.846
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

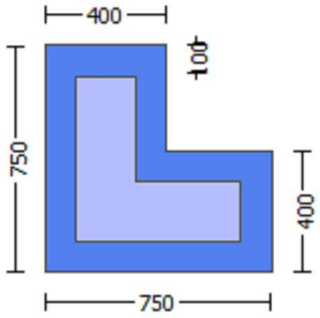
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

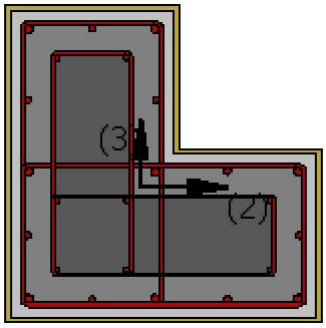
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
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
Secondary Member
Ribbed Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009

---

with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00

s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00

Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
            s2 = 250.00
         fywe1 = 694.45
         fywe2 = 694.45
         fce  = 33.00
      From ((5.A5), TBDY), TBDY: εcc = 0.00238888
         λc  = confinement factor = 1.03889
   εy1 = 0.0025
   εsh1 = 0.008
   ft1 = 833.34
   fy1 = 694.45
   εsu1 = 0.032
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/ld = 1.00
      εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esu1_nominal = 0.08,
      For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
      characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
      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 = 694.45
        with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
   εy2 = 0.0025
   εsh2 = 0.008
   ft2 = 833.34
   fy2 = 694.45
   εsu2 = 0.032
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/lb,min = 1.00
      εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esu2_nominal = 0.08,
      For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
      characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
      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 = 694.45
        with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
   εyv = 0.0025
   εshv = 0.008
   ftv = 833.34
   fyv = 694.45
   εsuv = 0.032
      using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
      and also multiplied by the shear_factor according to 15.7.1.4, with
      Shear_factor = 1.00
      lo/lou,min = lb/ld = 1.00
      εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
      From table 5A.1, TBDY: esuv_nominal = 0.08,
      considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
      For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
      characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
      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 = 694.45
        with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
   ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
   ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
   ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:

Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609

where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = -320844.41
Shear Force, V2 = -4866.131
Shear Force, V3 = 131.6809
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.05378656
θu = θy + θp = 0.05378656

 - Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00345707 ((4.29),Biskinis Phd))
My = 6.4998E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2436.529
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.05032949
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1

shear control ratio VyE/VCol0E = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18154.476
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

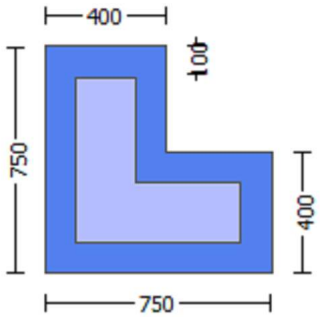
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

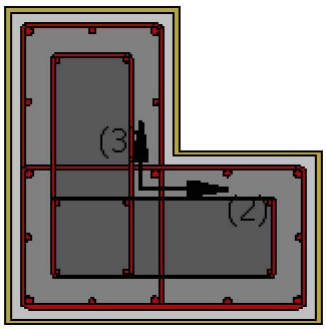
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##########
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -320844.41
Shear Force, Va = 131.6809
EDGE -B-
Bending Moment, Mb = -72349.636
Shear Force, Vb = -131.6809
BOTH EDGES
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 948969.187
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 948969.187
VCol = 948969.187
knl = 1.00
displacement_ductility_demand = 0.00587761

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 320844.41
Vu = 131.6809
d = 0.8*h = 600.00
Nu = 18154.476
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559
where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 251327.412 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 88467.249 is calculated for section web core, with:
d = 440.00
Av = 100530.965

fy = 500.00
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 = 500.00
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 <= 797164.595
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 = 2.0319315E-005
θy = (My*Ls/3)/EIeff = 0.00345707 ((4.29),Biskinis Phd))
My = 6.4998E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2436.529
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00214476
pc = 0.00416509

pv = 0.00378591
N = 18154.476
b = 750.00
δ'' = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

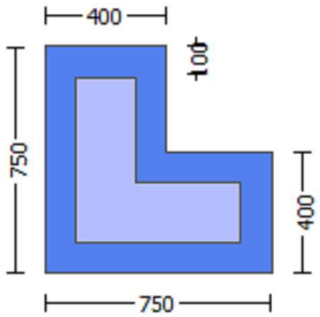
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

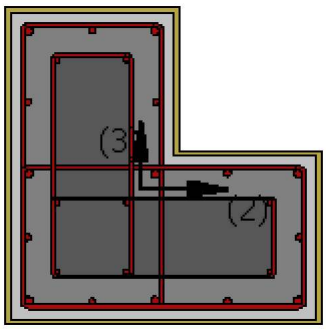
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 1.0898E+006
  knl = 1 (zero step-static loading)

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

  λ = 1 (normal-weight concrete)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 4.00
    Mu = 1518.01
    Vu = 0.00017144
   d = 0.8*h = 600.00
   Nu = 16273.607
   Ag = 300000.00
   From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
   where:
  Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
   Vs,j1 = 523602.964 is calculated for section web jacket, with:
     d = 600.00
     Av = 157079.633
     fy = 555.56
     s = 100.00
   Vs,j1 is multiplied by αCol,j1 = 1.00
     s/d = 0.16666667
   Vs,j2 = 279254.914 is calculated for section flange jacket, with:
     d = 320.00
     Av = 157079.633
     fy = 555.56
     s = 100.00
   Vs,j2 is multiplied by αCol,j2 = 1.00
     s/d = 0.3125
  Vs,core = Vs,c1 + Vs,c2 = 98297.73
   Vs,c1 = 98297.73 is calculated for section web core, with:
     d = 440.00
     Av = 100530.965
     fy = 555.56
     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 = 555.56

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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607

fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45

εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009

φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607

fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00

Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56

s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = -1.5109E+007
Shear Force, V2 = -4866.131
Shear Force, V3 = 131.6809
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.05473481
θu = θy + θp = 0.05473481

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00440532 ((4.29),Biskinis Phd))
My = 6.4998E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3104.846
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.05032949
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18154.476
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

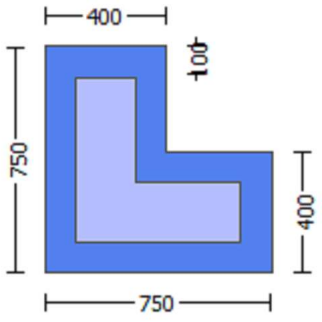
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

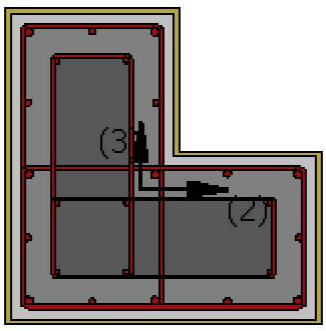
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -1.5109E+007
Shear Force, Va = -4866.131
EDGE -B-
Bending Moment, Mb = 505225.544
Shear Force, Vb = 4866.131
BOTH EDGES
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 1.1008E+006
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 1.1008E+006
VCol = 1.1008E+006
knl = 1.00
displacement_ductility_demand = 0.03726828

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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 505225.544
Vu = 4866.131
d = 0.8*h = 600.00
Nu = 18154.476
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559
where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 251327.412 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 471238.898 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 88467.249 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 <= 797164.595
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 = 1.5863445E-005
θy = (My*Ls/3)/EIeff = 0.00042566 ((4.29),Biskinis Phd))
My = 6.4998E+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 = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616

with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

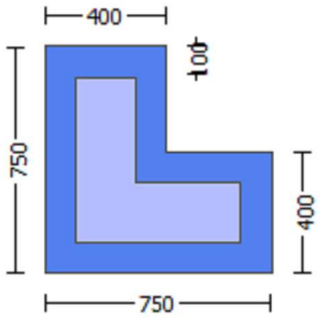
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

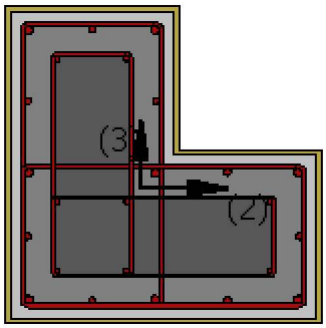
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment

direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34

fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009

---

with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3

MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = -72349.636
Shear Force, V2 = 4866.131
Shear Force, V3 = -131.6809
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.05110905
θu = θy + θp = 0.05110905

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00077956 ((4.29),Biskinis Phd))
My = 6.4998E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 549.4315
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.05032949
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18154.476
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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

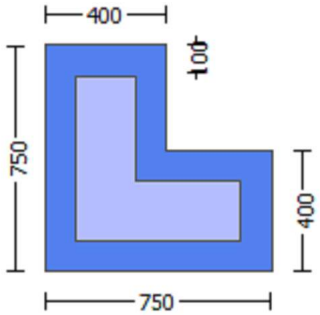
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

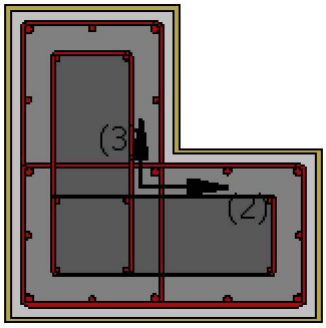
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##

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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
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 = -320844.41
Shear Force, Va = 131.6809
EDGE -B-
Bending Moment, Mb = -72349.636
Shear Force, Vb = -131.6809
BOTH EDGES
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 1.1008E+006
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 1.1008E+006
VCol = 1.1008E+006
knl = 1.00
displacement_ductility_demand = 1.0996272E-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 = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 72349.636
Vu = 131.6809
d = 0.8*h = 600.00
Nu = 18154.476
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 811033.559

where:
Vs,jacket = Vs,j1 + Vs,j2 = 722566.31
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 251327.412 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 88467.249
Vs,c1 = 88467.249 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 500.00
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 = 500.00
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 <= 797164.595
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 = 8.5722711E-009
θy = (My*Ls/3)/EIeff = 0.00077956 ((4.29),Biskinis Phd))
My = 6.4998E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 549.4315
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00214476
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

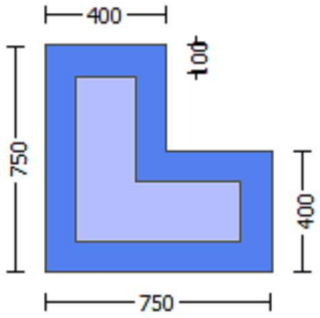
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

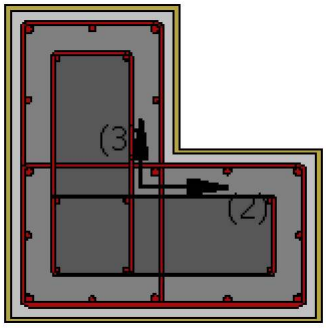
Analysis: Uniform +X

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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##########
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
Secondary Member
Ribbed Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.00017144
EDGE -B-
Shear Force, Vb = 0.00017144
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709

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 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00238888

λc = confinement factor = 1.03889

εy1 = 0.0025

εsh1 = 0.008

ft1 = 833.34

fy1 = 694.45

εsu1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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 = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 833.34

fy2 = 694.45

εsu2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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

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

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

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

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 = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025

εshv = 0.008

ftv = 833.34

fyv = 694.45

εsuv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

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

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00

s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.01
Vu = 0.00017144
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 523602.964 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 279254.914 is calculated for section flange jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00

Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.3125
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 98297.73 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
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 = -0.0001715
EDGE -B-
Shear Force, Vb = 0.0001715
BOTH EDGES
Axial Force, F = -16273.607
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 = 1.05752
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1525E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.7288E+009
Mu1+ = 1.1540E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.7288E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.7288E+009
Mu2+ = 1.1540E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.7288E+009, 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 = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.0226943E-005
Mu = 1.1540E+009
---
with full section properties:
b = 750.00
d = 707.00
d' = 43.00
v = 0.00093001
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34
fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0451341
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08764993
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07967042
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) = 0.05123276
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09949345
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09043572
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.09885678
Mu = MRc (4.14) = 1.1540E+009
φu = φsu (4.1) = 5.0226943E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 6.4288704E-005
Mu = 1.7288E+009
---
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174378
N = 16273.607
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01291652
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01291652
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.05541928
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 = 0.45746528
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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 = 293525.00 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) = 0.45746528
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, 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) = 3.0194
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 3.0194
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709
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 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00238888
λc = confinement factor = 1.03889
εy1 = 0.0025
εsh1 = 0.008
ft1 = 833.34
fy1 = 694.45
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 833.34
fy2 = 694.45
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 833.34

fyv = 694.45
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.16434361
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.08462644
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.14938203
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) = 0.20191317
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.10397236
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18353132
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.29596233
Mu = MRc (4.15) = 1.7288E+009
φu = φsu (4.1) = 6.4288704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0898E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0898E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609
where:

Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0898E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0898E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1518.777
Vu = 0.0001715
d = 0.8*h = 600.00
Nu = 16273.607
Ag = 300000.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 901155.609

where:
Vs,jacket = Vs,j1 + Vs,j2 = 802857.879
Vs,j1 = 279254.914 is calculated for section web jacket, with:
d = 320.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.3125
Vs,j2 = 523602.964 is calculated for section flange jacket, with:
d = 600.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.16666667
Vs,core = Vs,c1 + Vs,c2 = 98297.73
Vs,c1 = 0.00 is calculated for section web core, with:
d = 160.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.5625
Vs,c2 = 98297.73 is calculated for section flange core, with:
d = 440.00
Av = 100530.965
fy = 555.56
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 <= 915872.391
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 Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
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 = 505225.544
Shear Force, V2 = 4866.131
Shear Force, V3 = -131.6809
Axial Force, F = -18154.476
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0*θu = 0.05075515
θu = θy + θp = 0.05075515

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00042566 ((4.29),Biskinis Phd))
My = 6.4998E+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 = 1.5270E+014
factor = 0.30
Ag = 440000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
N = 18154.476
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.0901E+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 = 4.8675041E-006
with fy = 555.56
d = 707.00
ξy = 0.19281101
A = 0.01015738
B = 0.00446779
with pt = 0.00671904
pc = 0.00416509
pv = 0.00378591
N = 18154.476
b = 750.00
δ" = 0.06082037
Φy_comp = 1.6460425E-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 = 0.19183941
A = 0.01001908
B = 0.00440616
with Es = 200000.00
CONFIRMATION: ξy = 0.19281101 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.05032949
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1

shear control ratio VyE/VCol0E = 1.05752
d = d_external = 707.00
s = s_external = 0.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00671904
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00367709
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 = 100.00
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 = 18154.476
Ag = 440000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 555.56
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.01009575
b = 750.00
d = 707.00
f'cE = 33.00

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