Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

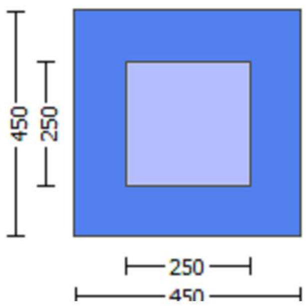
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

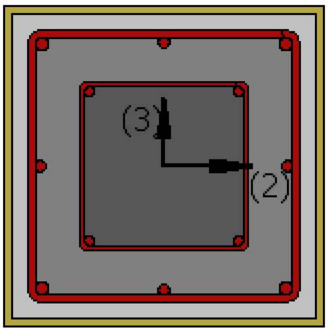
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.3098E+007
Shear Force, Va = -7697.601
EDGE -B-
Bending Moment, Mb = 0.06012619
Shear Force, Vb = 7697.601
BOTH EDGES
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 365324.682
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 429793.743

VCol = 429793.743
knl = 1.00
displacement_ductility_demand = 0.03746071

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 2.3098E+007
Vu = 7697.601
d = 0.8*h = 360.00
Nu = 7503.728
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00024357
θy = (My*Ls/3)/Eleff = 0.00650201 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.708
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7503.728
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

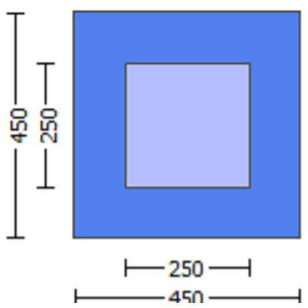
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

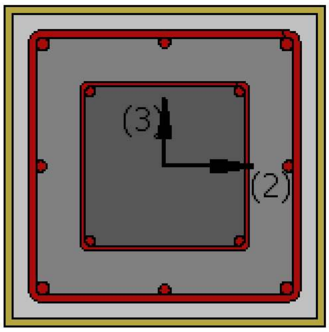
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55

##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00

d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00

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

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258

εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00

ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00

ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:

b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633

fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00

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

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267

af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274

bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -3.5391295E-010
Shear Force, V2 = -7697.601
Shear Force, V3 = 1.7235006E-013
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761

-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0027627
θu = θy + θp = 0.00325024

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00325024 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00430549
pc = 0.00620943
pv = 0.0021956
N = 7503.728
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7503.728
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

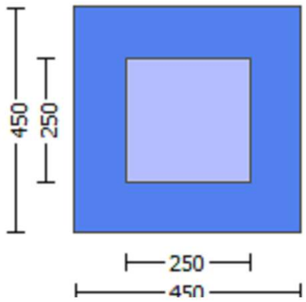
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

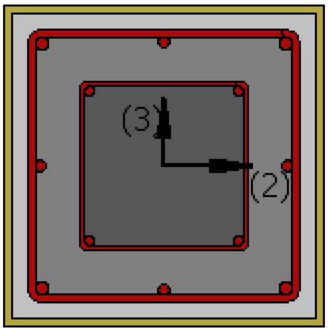
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##

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

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -3.5391295E-010
Shear Force, Va = 1.7235006E-013
EDGE -B-
Bending Moment, Mb = -1.6313530E-010
Shear Force, Vb = -1.7235006E-013
BOTH EDGES
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 447100.515
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 526000.605
VCol = 526000.605
knl = 1.00
displacement_ductility_demand = 0.00

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.5391295E-010
Vu = 1.7235006E-013
d = 0.8*h = 360.00
Nu = 7503.728
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:

Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 5.1751012E-023
θy = (My*Ls/3)/EIeff = 0.00325024 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7503.728

b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

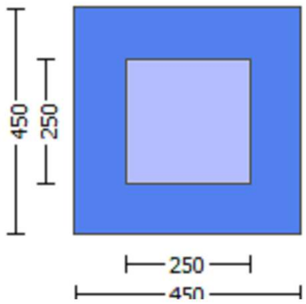
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

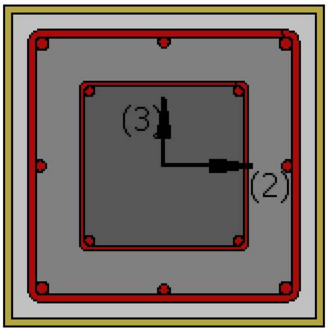
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu^* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417

λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234

Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247

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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-

Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556

bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696

ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00

v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00

fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175

$\varepsilon sh2 = 0.0048696$
ft2 = 479.7871
fy2 = 399.8226
$\varepsilon su2 = 0.0066488$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
$\varepsilon yv = 0.00152175$
$\varepsilon shv = 0.0048696$
ftv = 507.2537
fyv = 422.7114
$\varepsilon suv = 0.0066488$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00

ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -2.3098E+007
Shear Force, V2 = -7697.601
Shear Force, V3 = 1.7235006E-013
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00552671
θu = θy + θp = 0.00650201

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00650201 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.708
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00430549
pc = 0.00620943
pv = 0.0021956
N = 7503.728
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7503.728
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

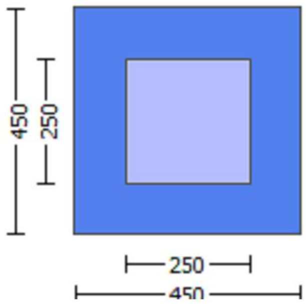
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

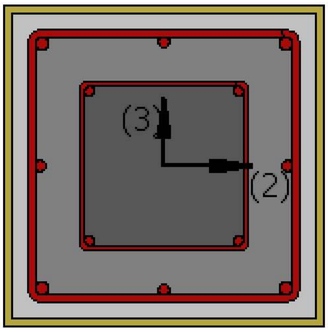
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.3098E+007
Shear Force, Va = -7697.601
EDGE -B-
Bending Moment, Mb = 0.06012619
Shear Force, Vb = 7697.601
BOTH EDGES
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 447100.515
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 526000.605
VCol = 526000.605
knl = 1.00
displacement_ductility_demand = 0.19669705

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.06012619
Vu = 7697.601
d = 0.8*h = 360.00
Nu = 7503.728
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333

Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00012786
θy = (My*Ls/3)/Eleff = 0.00065005 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7503.728
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00

h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

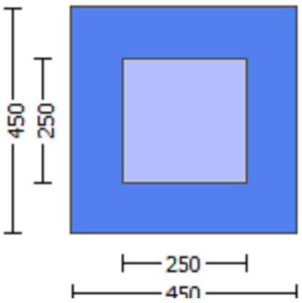
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

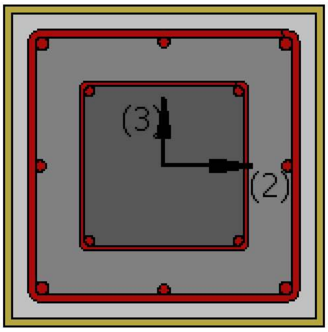
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00

Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696

ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005

Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00

fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00

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

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00

ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:

b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00

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

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258

lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00

Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031

d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00

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

Stepwise Properties

Bending Moment, M = -1.6313530E-010
Shear Force, V2 = 7697.601
Shear Force, V3 = -1.7235006E-013
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0027627
θu = θy + θp = 0.00325024

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00325024 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00430549
pc = 0.00620943
pv = 0.0021956
N = 7503.728
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1

shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7503.728
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

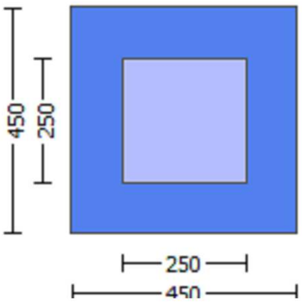
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

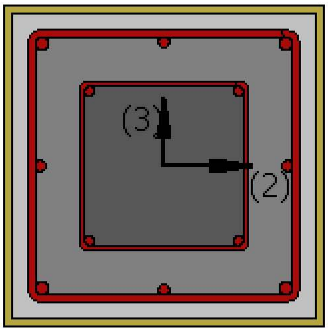
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -3.5391295E-010
Shear Force, Va = 1.7235006E-013
EDGE -B-
Bending Moment, Mb = -1.6313530E-010
Shear Force, Vb = -1.7235006E-013
BOTH EDGES
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 447100.515
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 526000.605
VCol = 526000.605
knl = 1.00
displacement_ductility_demand = 0.00

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.6313530E-010
Vu = 1.7235006E-013
d = 0.8*h = 360.00
Nu = 7503.728
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 9.3519433E-023
θy = (My*Ls/3)/Eleff = 0.00325024 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7503.728
b = 450.00
δ" = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515

B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

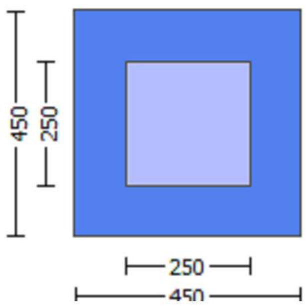
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

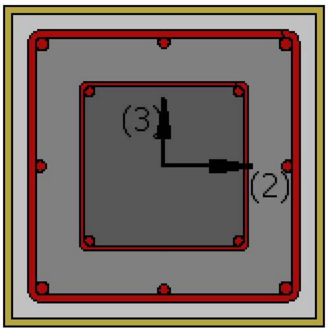
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00

-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923

ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696

ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008

φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00

n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008

Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417

λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234

Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00

Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:

d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)

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

Stepwise Properties

Bending Moment, M = 0.06012619
Shear Force, V2 = 7697.601
Shear Force, V3 = -1.7235006E-013
Axial Force, F = -7503.728
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00055254
θu = θy + θp = 0.00065005

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00065005 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7503.728
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806747E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591435
A = 0.0147239
B = 0.00818869
with pt = 0.00430549
pc = 0.00620943

pv = 0.0021956
N = 7503.728
b = 450.00
δ" = 0.10565111
Φy_comp = 2.2127278E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471862
A = 0.01452515
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7503.728
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

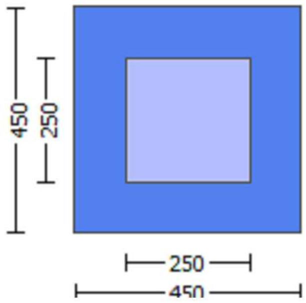
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

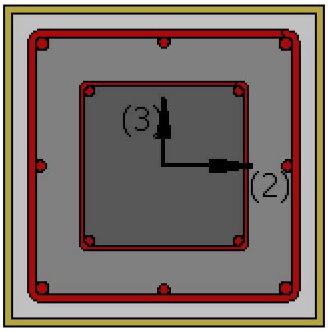
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -3.5352E+007
Shear Force, Va = -11781.223
EDGE -B-
Bending Moment, Mb = 0.09202348
Shear Force, Vb = 11781.223
BOTH EDGES
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 365324.544
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 429793.581
VCol = 429793.581
knl = 1.00
displacement_ductility_demand = 0.05733393

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.5352E+007
Vu = 11781.223
d = 0.8*h = 360.00
Nu = 7502.094
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00037279
θy = (My*Ls/3)/Eleff = 0.006502 ((4.29),Biskinis Phd))
My = 1.7613E+008

Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.708
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

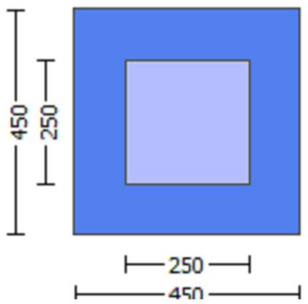
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

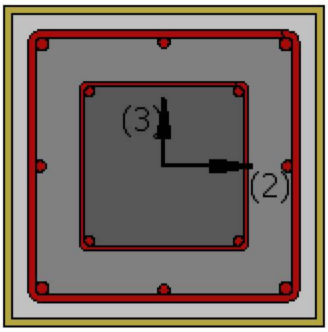
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923

ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696

ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008

$\varphi u = \varphi su$ (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
$\lambda = 1$
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu^* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00

n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00

Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44

s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417

λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234

Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247

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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -5.3402437E-010
Shear Force, V2 = -11781.223
Shear Force, V3 = 2.6378276E-013
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257

-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03558642
θu = θy + θp = 0.04186638

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00325023 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00430549
pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517

B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.03861614
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7502.094
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

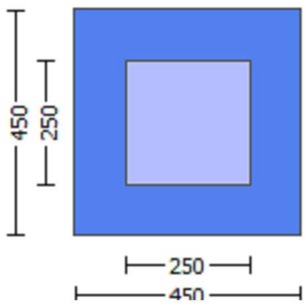
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

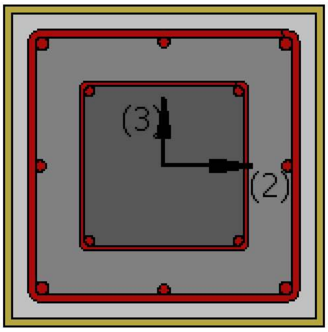
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column

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

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -5.3402437E-010
Shear Force, Va = 2.6378276E-013
EDGE -B-
Bending Moment, Mb = -2.5732098E-010
Shear Force, Vb = -2.6378276E-013
BOTH EDGES
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 447100.239
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 526000.281
VCol = 526000.281
knl = 1.00
displacement_ductility_demand = 0.00

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 5.3402437E-010
Vu = 2.6378276E-013
d = 0.8*h = 360.00
Nu = 7502.094

Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 7.9205223E-023
θy = (My*Ls/3)/Eleff = 0.00325023 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00620943

pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

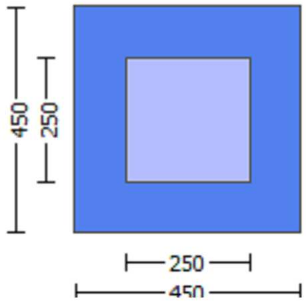
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

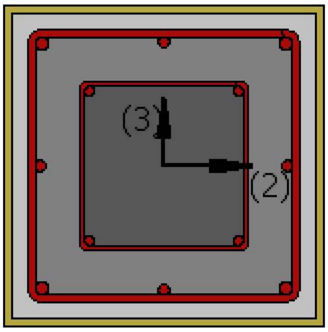
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417

λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234

Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00

From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247

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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-

Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556

bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696

ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80

ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00

v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00

fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00

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

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175

εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00

ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -3.5352E+007
Shear Force, V2 = -11781.223
Shear Force, V3 = 2.6378276E-013
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1137.257
-Compression: Aslc = 1539.38
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03835042
θu = θy + θp = 0.04511814

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.006502 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.708
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00430549
pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00

cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.03861614
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7502.094
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

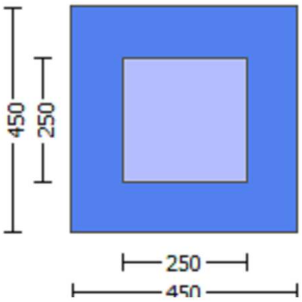
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

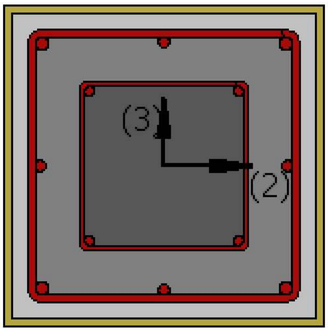
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -3.5352E+007
Shear Force, Va = -11781.223
EDGE -B-
Bending Moment, Mb = 0.09202348
Shear Force, Vb = 11781.223
BOTH EDGES
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 447100.239
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 526000.281
VCol = 526000.281
knl = 1.00
displacement_ductility_demand = 0.30104645

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.09202348
Vu = 11781.223
d = 0.8*h = 360.00
Nu = 7502.094
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333

Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00019569
θy = (My*Ls/3)/EIeff = 0.00065005 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00

h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

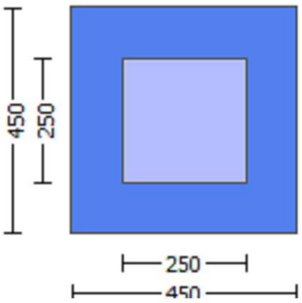
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

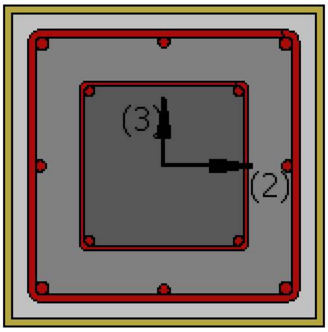
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1

db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00

Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696

ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005

Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00

fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00

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

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00

ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:

b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00

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

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258

lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00

Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031

d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00

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

Stepwise Properties

Bending Moment, M = -2.5732098E-010
Shear Force, V2 = 11781.223
Shear Force, V3 = -2.6378276E-013
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03558642
θu = θy + θp = 0.04186638

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00325023 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00430549
pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.03861614
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1

shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7502.094
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

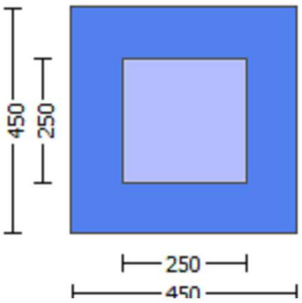
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

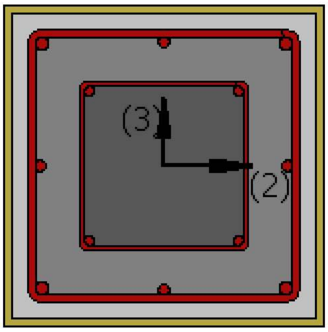
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -5.3402437E-010
Shear Force, Va = 2.6378276E-013
EDGE -B-
Bending Moment, Mb = -2.5732098E-010
Shear Force, Vb = -2.6378276E-013
BOTH EDGES
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 447100.239
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 526000.281
VCol = 526000.281
knl = 1.00
displacement_ductility_demand = 0.00

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 = 22.22222, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.5732098E-010
Vu = 2.6378276E-013
d = 0.8*h = 360.00
Nu = 7502.094
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 129852.496
where:
Vs1 = 62831.853 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 67020.643 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 400.00
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 507312.442
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.4313203E-022
θy = (My*Ls/3)/EIeff = 0.00325023 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00620943
pc = 0.00620943
pv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = pt + pc + pv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517

B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

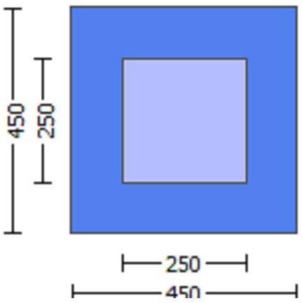
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

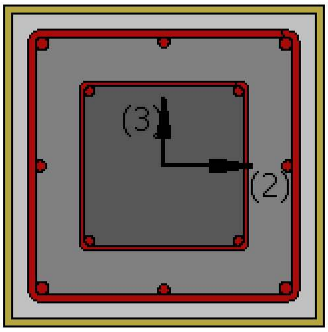
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 2.0531359E-031
EDGE -B-
Shear Force, Vb = -2.0531359E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
    -Tension: Aslt = 0.00

-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008
Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258

εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923

ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696

ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008

φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

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

Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00

n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4404090E-011
Vu = 2.0531359E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.10542
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7162834E-031
EDGE -B-
Shear Force, Vb = 2.7162834E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.26068017
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 147952.607
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.2193E+008
Mu1+ = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.2193E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.2193E+008

Mu2+ = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.2193E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417

λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234

Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9632832E-005
Mu = 2.2193E+008
----
with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00124204
N = 7506.808
fc = 33.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01393923
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01393923
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.06811101
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

ωfy = 0.06628267
af = 0.54930041
b = 450.00
h = 450.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00451556
bw = 450.00
effective stress from (A.35), ff,e = 881.8461

R = 40.00
Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
fu,f = 1055.00
Ef = 64828.00
εu,f = 0.015
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.14546167
ase1 = 0.12623274
bo_1 = 390.00
ho_1 = 390.00
Σbi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.18853448
bo_2 = 242.00
ho_2 = 242.00
Σbi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 1.38262
Expression ((5.4d), TBDY) 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 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 1.38262
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00116355
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00103427
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 300.00
s2 = 120.00
fywe1 = 694.45
fywe2 = 555.55
fce = 33.00
From ((5.A5), TBDY), TBDY: εcc = 0.00305417
λc = confinement factor = 1.10542
εy1 = 0.00152175
εsh1 = 0.0048696
ft1 = 479.7871
fy1 = 399.8226
εsu1 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.00152175
εsh2 = 0.0048696
ft2 = 479.7871
fy2 = 399.8226
εsu2 = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.33981258
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
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 = 399.8226
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.00152175
εshv = 0.0048696
ftv = 507.2537
fyv = 422.7114
εsuv = 0.0066488
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.33981258
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
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 = 422.7114
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.0752324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.0752324
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.02812438
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 36.47874
εcc (5A.5, TBDY) = 0.00305417
λc = confinement factor = 1.10542
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09371431
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.09371431
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.03503353
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.16791801
Mu = MRc (4.14) = 2.2193E+008
φu = φsu (4.1) = 1.9632832E-005

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.33981258
lb = 300.00
ld = 882.8396
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 655.558
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 567563.724

Calculation of Shear Strength at edge 1, Vr1 = 567563.724
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00

Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 567563.724
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 567563.724
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 = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.0463738E-012
Vu = 2.7162834E-031
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 144280.365
where:
Vs1 = 69813.729 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 555.56
s = 300.00
Vs1 is multiplied by αCol1 = 0.66666667
s/d = 0.83333333
Vs2 = 74466.637 is calculated for core, with:

d = 200.00
Av = 100530.965
fy = 444.44
s = 120.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.60
Vf ((11-3)-(11.4), ACI 440) = 214457.247
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) = 407.00
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 <= 579413.096
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)

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

Stepwise Properties

Bending Moment, M = 0.09202348
Shear Force, V2 = 11781.223
Shear Force, V3 = -2.6378276E-013
Axial Force, F = -7502.094
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 829.3805
-Compression: Asl,com,jacket = 829.3805
-Middle: Asl,mid,jacket = 402.1239
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 0.00
Mean Diameter of Tension Reinforcement, DbL = 16.80

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03337626
θu = θy + θp = 0.03926619

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00065005 ((4.29),Biskinis Phd))
My = 1.7613E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.7095E+013
factor = 0.30
Ag = 202500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765
N = 7502.094
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 9.0315E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.1806717E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^2/3) = 374.3546
d = 407.00
ξy = 0.25591399
A = 0.01472387
B = 0.00818866
with pt = 0.00430549
pc = 0.00620943

ρv = 0.0021956
N = 7502.094
b = 450.00
δ'' = 0.10565111
Φy_comp = 2.2127287E-005
with fc* (12.3, (ACI 440)) = 34.40847
fc = 33.00
fl = 0.82797802
b = 450.00
h = 450.00
Ag = 202500.00
From (12.9), ACI 440: ka = 0.54261599
ρg = ρt + ρc + ρv = 0.01461445
rc = 40.00
Ae/Ac = 0.54261599
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 = 0.25471852
A = 0.01452517
B = 0.00807924
with Es = 200000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.42476573
lb = 300.00
ld = 706.2717
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
λ = 1
db = 16.66667
Mean strength value of all re-bars: fy = 524.4464
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.98765, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
ψt = 1.00
ψs = 0.80
ψe = 1.00
cb = 25.00
Ktr = 2.86234
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 300.00
n = 12.00

- Calculation of θp -

From table 10-8: θp = 0.03861614
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 0.26068017
d = d_external = 407.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00430549
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00116355
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 450.00
s1 = 300.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00103427
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 250.00
s2 = 120.00
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 = 7502.094
Ag = 202500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.98765
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9972
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 503.2682
pl = Area_Tot_Long_Rein/(b*d) = 0.01461445
b = 450.00
d = 407.00
f'cE = 28.98765

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
