Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

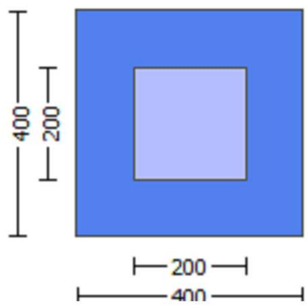
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

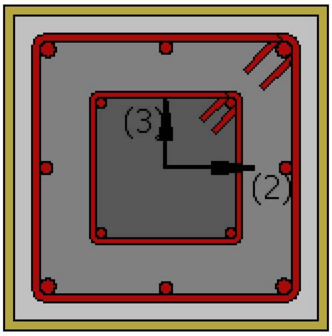
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.7042E+007
Shear Force, Va = -5679.087
EDGE -B-
Bending Moment, Mb = 0.01757656
Shear Force, Vb = 5679.087
BOTH EDGES
Axial Force, F = -5974.535
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 = 466063.025
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 466063.025

VCol = 466063.025
knl = 1.00
displacement_ductility_demand = 0.01904364

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7042E+007
Vu = 5679.087
d = 0.8*h = 320.00
Nu = 5974.535
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00029079
θy = (My*Ls/3)/EIeff = 0.01526943 ((4.29),Biskinis Phd))
My = 2.5335E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.914
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

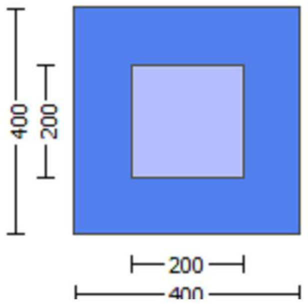
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

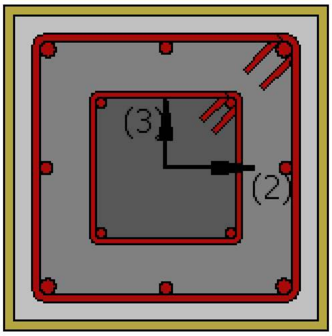
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

---

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

---

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008

----

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = 1.5641268E-009
Shear Force, V2 = -5679.087
Shear Force, V3 = -6.1222295E-013
Axial Force, F = -5974.535
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 = 0.01254957
θu = θy + θp = 0.01254957

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00491718
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.535
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

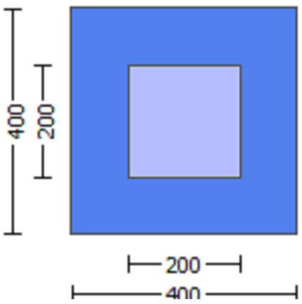
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

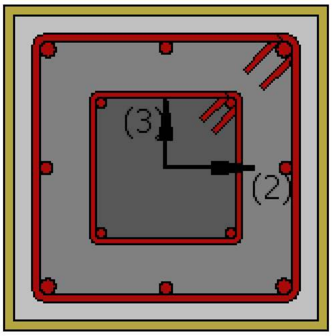
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.5641268E-009
Shear Force, Va = -6.1222295E-013
EDGE -B-
Bending Moment, Mb = 2.7294386E-010
Shear Force, Vb = 6.1222295E-013
BOTH EDGES
Axial Force, F = -5974.535
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 = 540153.014
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 540153.014
VCol = 540153.014
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 = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.5641268E-009
Vu = 6.1222295E-013
d = 0.8*h = 320.00
Nu = 5974.535
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.2557975E-020
θy = (My*Ls/3)/Eleff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ" = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

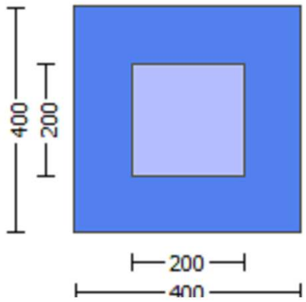
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

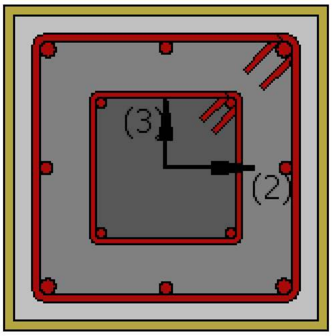
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = -1.7042E+007
Shear Force, V2 = -5679.087
Shear Force, V3 = -6.1222295E-013
Axial Force, F = -5974.535
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 = 0.02018661
θu = θy + θp = 0.02018661

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01526943 ((4.29),Biskinis Phd))
My = 2.5335E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.914
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

$\Phi y\_ten = 1.2236249E-005$
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00491718
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.535
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

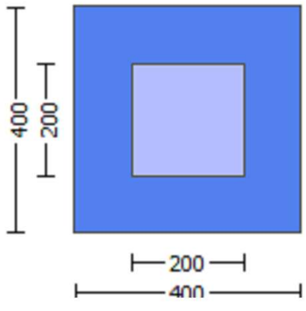
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

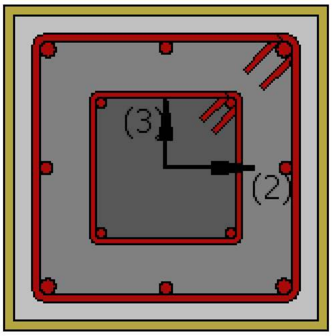
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.7042E+007
Shear Force, Va = -5679.087
EDGE -B-
Bending Moment, Mb = 0.01757656
Shear Force, Vb = 5679.087
BOTH EDGES
Axial Force, F = -5974.535
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 = 540153.014
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 540153.014
VCol = 540153.014
knl = 1.00

displacement_ductility_demand = 0.10089234

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.01757656
Vu = 5679.087
d = 0.8*h = 320.00
Nu = 5974.535
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00015401
θy = (My*Ls/3)/Eleff = 0.00152648 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

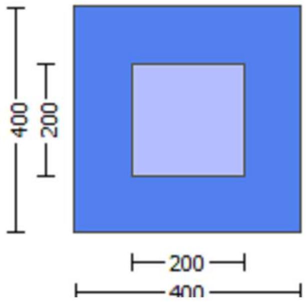
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

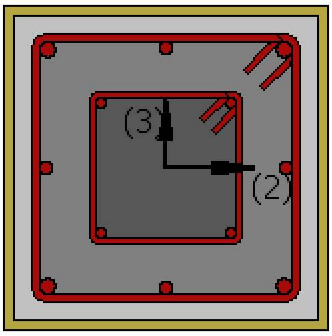
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

$\varepsilon sh1 = 0.008$
ft1 = 937.50
fy1 = 781.25
$\varepsilon su1 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
$\varepsilon su1$ = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and $\varepsilon y1, \varepsilon sh1$,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
$\varepsilon y2 = 0.0025$
$\varepsilon sh2 = 0.008$
ft2 = 937.50
fy2 = 781.25
$\varepsilon su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and $\varepsilon y2, \varepsilon sh2$,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
$\varepsilon yv = 0.0025$
$\varepsilon shv = 0.008$
ftv = 937.50
fyv = 781.25
$\varepsilon suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and $\varepsilon yv, \varepsilon shv$,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008

----

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = 2.7294386E-010
Shear Force, V2 = 5679.087
Shear Force, V3 = 6.1222295E-013
Axial Force, F = -5974.535
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 = 0.01254957
θu = θy + θp = 0.01254957

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00491718
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.535
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

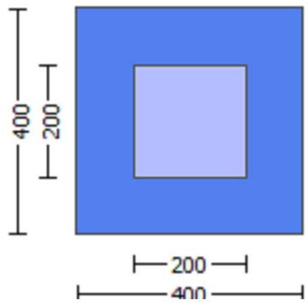
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

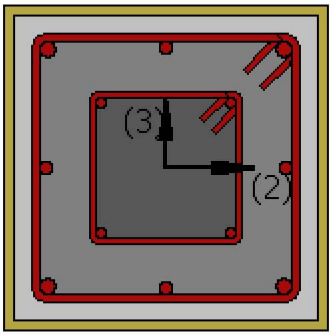
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.5641268E-009
Shear Force, Va = -6.1222295E-013
EDGE -B-
Bending Moment, Mb = 2.7294386E-010
Shear Force, Vb = 6.1222295E-013
BOTH EDGES
Axial Force, F = -5974.535
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 = 540153.014
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 540153.014
VCol = 540153.014
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 = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7294386E-010
Vu = 6.1222295E-013
d = 0.8*h = 320.00
Nu = 5974.535
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 9.5280082E-021
θy = (My*Ls/3)/Eleff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

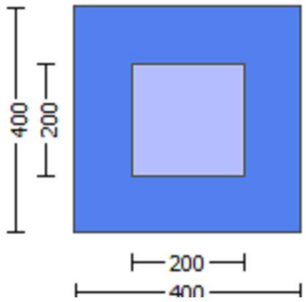
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

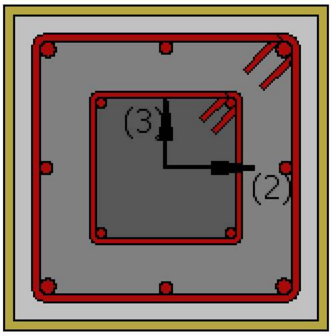
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008

----

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = 0.01757656
Shear Force, V2 = 5679.087
Shear Force, V3 = 6.1222295E-013
Axial Force, F = -5974.535
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 = 0.00644366
θu = θy + θp = 0.00644366

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00152648 ((4.29),Biskinis Phd))
My = 2.5335E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.535
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236249E-005
with fy = 625.00
d = 357.00
ξy = 0.28462542
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.535
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808790E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424569
A = 0.01864943
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00491718
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.535
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

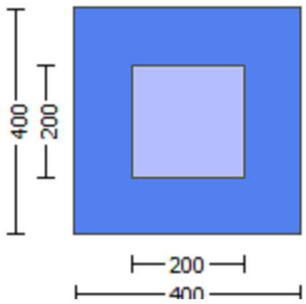
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

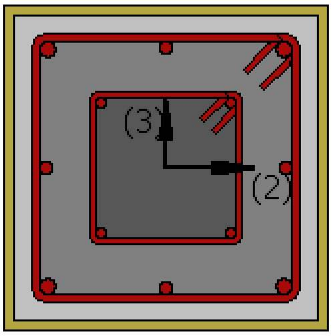
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3637E+007
Shear Force, Va = -4544.145
EDGE -B-
Bending Moment, Mb = 0.01406396
Shear Force, Vb = 4544.145
BOTH EDGES
Axial Force, F = -5974.99
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 = 466063.07
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 466063.07
VCol = 466063.07
knl = 1.00

displacement_ductility_demand = 0.01523784

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.3637E+007
Vu = 4544.145
d = 0.8*h = 320.00
Nu = 5974.99
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00023267
θy = (My*Ls/3)/Eleff = 0.01526943 ((4.29),Biskinis Phd))
My = 2.5335E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.914
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

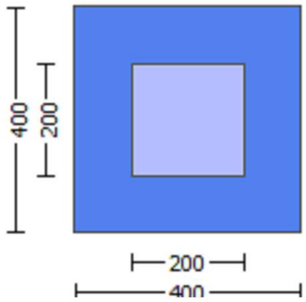
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

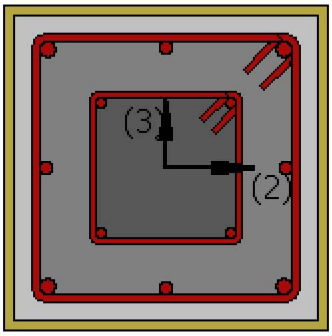
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

$\varepsilon y2 = 0.0025$
$\varepsilon sh2 = 0.008$
ft2 = 937.50
fy2 = 781.25
$\varepsilon su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and $\varepsilon y2$,$\varepsilon sh2$,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
$\varepsilon y1$,$\varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
$\varepsilon yv = 0.0025$
$\varepsilon shv = 0.008$
ftv = 937.50
fyv = 781.25
$\varepsilon suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
$\varepsilon y1$,$\varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
$\varphi u = \varphi su$ (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

---

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

---

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

φu = 0.0001081

Mu = 3.8975E+008

----

with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.00139515

N = 5976.808

fc = 30.00

εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659

ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913

where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513

af = 0.57333333

b = 400.00

h = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00

effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333

b = 400.00

h = 400.00

From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508

bw = 400.00

effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288

bo_1 = 340.00

ho_1 = 340.00

Σbi2_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288

bo_2 = 192.00

ho_2 = 192.00

Σbi2_2 = 147456.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699

Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = 1.2509360E-009
Shear Force, V2 = -4544.145
Shear Force, V3 = -4.8987279E-013
Axial Force, F = -5974.99
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 = 0.04447222
θu = θy + θp = 0.04447222

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03683983
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.99
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

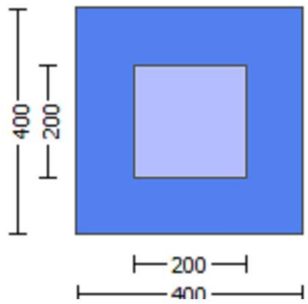
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

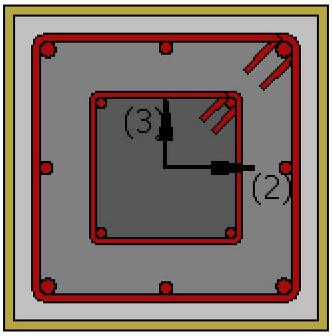
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.2509360E-009
Shear Force, Va = -4.8987279E-013
EDGE -B-
Bending Moment, Mb = 2.1900397E-010
Shear Force, Vb = 4.8987279E-013
BOTH EDGES
Axial Force, F = -5974.99
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 = 540153.104
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 540153.104
VCol = 540153.104
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 = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.2509360E-009
Vu = 4.8987279E-013
d = 0.8*h = 320.00
Nu = 5974.99
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.8049859E-020
θy = (My*Ls/3)/EIeff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

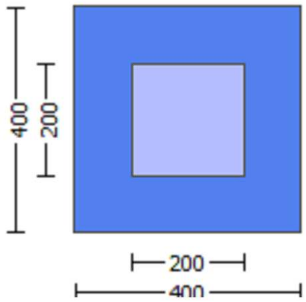
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

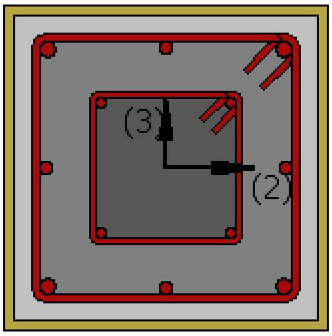
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and $\varepsilon yv, \varepsilon shv, ftv, fyv$, it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1, ft1, fy1$, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
$\varphi u = \varphi su$ (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu^* = shear_factor * Max($\varepsilon cu, \varepsilon cc$) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = -1.3637E+007
Shear Force, V2 = -4544.145
Shear Force, V3 = -4.8987279E-013
Axial Force, F = -5974.99
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 = 0.05210926
θu = θy + θp = 0.05210926

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01526943 ((4.29),Biskinis Phd))
My = 2.5335E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.914
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03683983
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.99
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

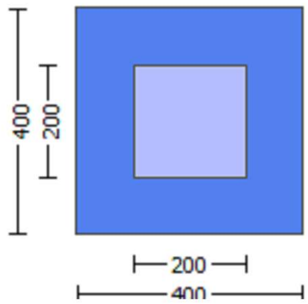
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

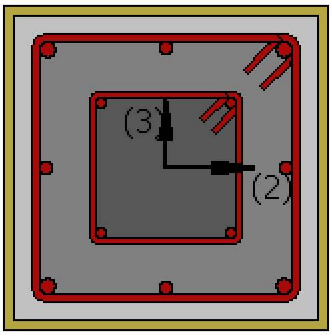
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3637E+007
Shear Force, Va = -4544.145
EDGE -B-
Bending Moment, Mb = 0.01406396
Shear Force, Vb = 4544.145
BOTH EDGES
Axial Force, F = -5974.99
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 = 540153.104
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 540153.104
VCol = 540153.104
knl = 1.00

displacement_ductility_demand = 0.08072941

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.01406396
Vu = 4544.145
d = 0.8*h = 320.00
Nu = 5974.99
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00012323
θy = (My*Ls/3)/Eleff = 0.00152648 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

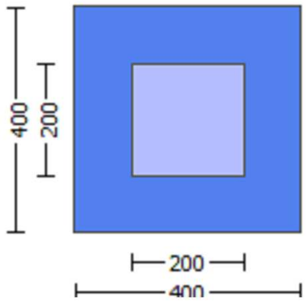
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

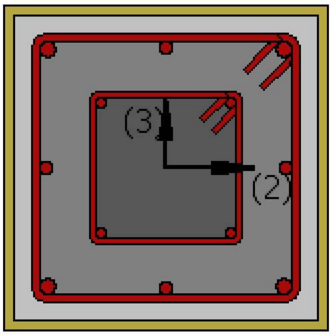
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

$\varepsilon sh1 = 0.008$
ft1 = 937.50
fy1 = 781.25
$\varepsilon su1 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008

----

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = 2.1900397E-010
Shear Force, V2 = 4544.145
Shear Force, V3 = 4.8987279E-013
Axial Force, F = -5974.99
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 = 0.04447222
θu = θy + θp = 0.04447222

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03683983
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.99
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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

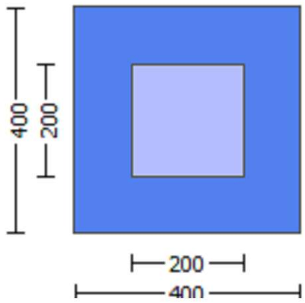
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

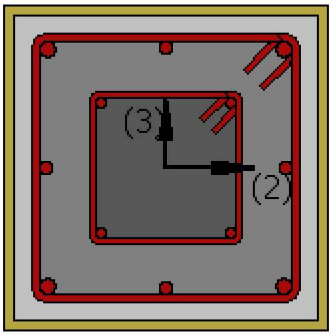
Analysis: Uniform +X

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 = 1.00
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 = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 28781.504
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 = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 37.50
Existing material: Steel Strength, fs = fsm = 625.00
##
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.2509360E-009
Shear Force, Va = -4.8987279E-013
EDGE -B-
Bending Moment, Mb = 2.1900397E-010
Shear Force, Vb = 4.8987279E-013
BOTH EDGES
Axial Force, F = -5974.99
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 = 540153.104
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 540153.104
VCol = 540153.104
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 = 21.25, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.1900397E-010
Vu = 4.8987279E-013
d = 0.8*h = 320.00
Nu = 5974.99
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412
where:
Vs1 = 251327.412 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 500.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 391973.036
bw = 400.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 7.6238762E-021
θy = (My*Ls/3)/Eleff = 0.00763239 ((4.29),Biskinis Phd))
My = 2.5335E+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 = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00796398
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

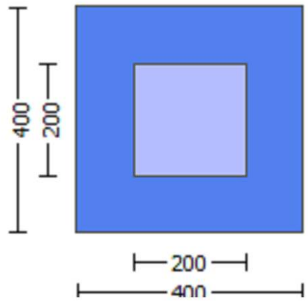
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

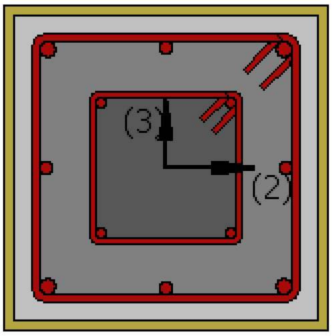
Analysis: Uniform +X

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

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

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -5.7032647E-033
EDGE -B-
Shear Force, Vb = 5.7032647E-033
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025

εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882

Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513

af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992

εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.0362063E-012
Vu = 5.7032647E-033
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
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 = 781.25
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 781.25
###
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.14466
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 1.2325952E-032
EDGE -B-
Shear Force, Vb = -1.2325952E-032
BOTH EDGES
Axial Force, F = -5976.808
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 = 0.39292559
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 259835.208
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.8975E+008
Mu1+ = 3.8975E+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- = 3.8975E+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-) = 3.8975E+008
Mu2+ = 3.8975E+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- = 3.8975E+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 = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*ρsh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288

ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50

fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008

----

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 0.0001081
Mu = 3.8975E+008
----
with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.00139515
N = 5976.808
fc = 30.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01685659
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01685659
ωwe ((5.4c), TBDY) = ase*psh,min*fywe/fce+Min(ωfx, ωfy) = 0.11149913
where ωf = af*pf*ffe/fce is accounting for FRP contribution like EC8-part3 A.4.4.3(6)

ωfx = 0.08352513
af = 0.57333333
b = 400.00
h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

ωfy = 0.08352513
af = 0.57333333
b = 400.00

h = 400.00
From EC8 A4.4.3(6), pf = 2tf/bw = 0.00508
bw = 400.00
effective stress from (A.35), ff,e = 860.3348

R = 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 = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
Σbi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
Σbi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.46066
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.46066
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 200.00

Asec = 160000.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: εcc = 0.00344664
λc = confinement factor = 1.14466
εy1 = 0.0025
εsh1 = 0.008
ft1 = 937.50
fy1 = 781.25
εsu1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsu1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and εy1,εsh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 781.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 937.50
fy2 = 781.25
εsu2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
εsu2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 781.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 937.50
fyv = 781.25
εsuv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 781.25
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.20739535
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20739535
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.07333316
and confined core properties:
b = 340.00
d = 327.00
d' = 13.00
fcc (5A.2, TBDY) = 34.33992
εcc (5A.5, TBDY) = 0.00344664
λc = confinement factor = 1.14466
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26637935
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26637935
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.09418938
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
ξsu (4.9) = 0.17082882
Mu = MRc (4.14) = 3.8975E+008
φu = φsu (4.1) = 0.0001081

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 661283.497

Calculation of Shear Strength at edge 1, Vr1 = 661283.497
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:
Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 661283.497
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 661283.497
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 = 31.875, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.7943299E-013
Vu = 1.2325952E-032
d = 0.8*h = 320.00
Nu = 5976.808
Ag = 160000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 314159.265
where:

Vs1 = 314159.265 is calculated for jacket, with:
d = 320.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.3125
Vs2 = 0.00 is calculated for core, with:
d = 160.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.5625
Vf ((11-3)-(11.4), ACI 440) = 188111.148
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) = 357.00
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 <= 480066.965
bw = 400.00

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 = 1.00
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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 37.50
Existing material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

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

Stepwise Properties

Bending Moment, M = 0.01406396
Shear Force, V2 = 4544.145
Shear Force, V3 = 4.8987279E-013
Axial Force, F = -5974.99
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 = 0.0383663
θu = θy + θp = 0.0383663

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00152648 ((4.29),Biskinis Phd))
My = 2.5335E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.6597E+013
factor = 0.30
Ag = 160000.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 31.875
N = 5974.99
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 5.5323E+013

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)

Φy_ten = 1.2236250E-005
with fy = 625.00
d = 357.00
ξy = 0.28462548
A = 0.0188109
B = 0.01056776
with pt = 0.00653733
pc = 0.00796398
pv = 0.00281599
N = 5974.99
b = 400.00
δ'' = 0.12044818
Φy_comp = 2.1808788E-005
with fc* (12.3, (ACI 440)) = 31.65043
fc = 30.00
fl = 0.93147527
b = 400.00
h = 400.00
Ag = 160000.00
From (12.9), ACI 440: ka = 0.56518315
ρg = pt + pc + pv = 0.01874396
rc = 40.00
Ae/Ac = 0.56518315
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 = 25742.96
ξy = 0.28424573
A = 0.01864942
B = 0.01050082
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03683983
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.39292559
d = d_external = 357.00
s = s_external = 0.00
ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00653733
jacket: ρs1 = Av1*h1/(s1*Ag) = 0.00392699
Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
h1 = 400.00
s1 = 100.00
core: ρs2 = Av2*h2/(s2*Ag) = 0.00050265
Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
h2 = 200.00
s2 = 250.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 5974.99
Ag = 160000.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 31.875
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 625.00
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 625.00

pl = Area_Tot_Long_Rein/(b*d) = 0.01874396
b = 400.00
d = 357.00
f'cE = 31.875

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