Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

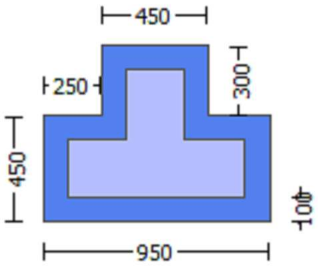
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

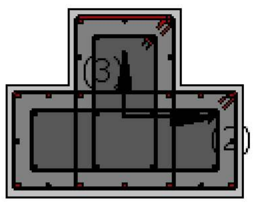
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.9854E+009
Shear Force, Va = -716139.537
EDGE -B-
Bending Moment, Mb = -3.5795E+008
Shear Force, Vb = 716139.537
BOTH EDGES
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3191.858
-Compression: Aslc = 3499.734
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 793342.593
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 991678.242
VCol = 1.1571E+006
knl = 0.85705856
displacement_ductility_demand = 3.90589

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.64793
Mu = 1.9854E+009
Vu = 716139.537
d = 0.8*h = 760.00
Nu = 5.0716E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 980981.156
where:
Vs,jacket = Vs,j1 + Vs,j2 = 879645.943
Vs,j1 = 282743.339 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 596902.604 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 101335.213
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 101335.213 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 723217.666
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.01287864
θy = (My*Ls/3)/EIeff = 0.00329724 ((4.29),Biskinis Phd))
My = 1.6308E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2772.431
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

$\Phi y = Min(\Phi y\_ten, \Phi y\_com)$
$\Phi y\_ten = 6.3767581E-006$
with fy = 601.9953
d = 907.00
$\xi y = 0.47957772$
A = 0.0370359
B = 0.02922707
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0716E+006
b = 450.00
δ" = 0.04740904
$\Phi y\_comp = 2.6024973E-006$
with fc = 18.00
Ec = 19940.411
$\xi y = 0.68835635$
A = -0.02184193
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 2

column C1, Floor 1

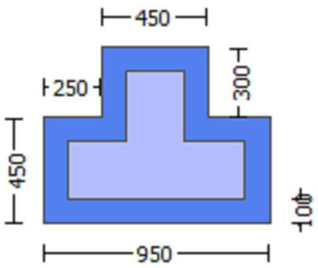
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

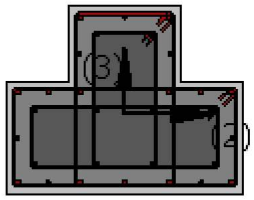
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-

Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025

εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied

--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, $\rho 1$, $\rho 2$, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ^*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
$\varphi u = \varphi cu$ (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
   b = 450.00
   d = 707.00
   d' = 43.00
   v = 0.88729156
      N = 5.0813E+006
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
      The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00

s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00

Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006

EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->

v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25

fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633

fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:

d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -5.5401E+008
Shear Force, V2 = -716139.537
Shear Force, V3 = 3.11526
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3191.858
-Compression: Aslc = 3499.734
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2475.575
-Compression: Asl,com = 1539.38

-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1859.823
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 615.7522
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.72727

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01009045
θu = θy + θp = 0.01261306

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01261306 ((4.29),Biskinis Phd))
My = 1.9034E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.3868598E-006
with fy = 601.9953
d = 707.00
ξy = 0.42365327
A = 0.02250607
B = 0.01848214
with pt = 0.00368581
pc = 0.00229194
pv = 0.00398517
N = 5.0716E+006
b = 950.00
δ'' = 0.06082037
Φy_comp = 4.5684036E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.50306838
A = -0.01327296
B = 0.00593898
with Es = 200000.00
CONFIRMATION: ξy = 0.50306838 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

 - Calculation of θp -

From table 10-8: θp = 0.00
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VCol0E = 1.92314
   d = d_external = 707.00
   s = s_external = 100.00
 - ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.0035764
   jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00301593
        Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
        Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
        s1 = 100.00
   core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00056047
        Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
        Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
        s2 = 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 = 5.0716E+006
     Ag = 562500.00
     f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
     fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
     fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 609.3286
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292
   b = 950.00
   d = 707.00
     f'cE = 15.20

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

Calculation No. 3

column C1, Floor 1

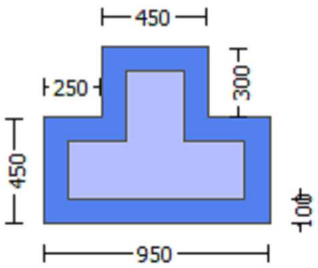
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

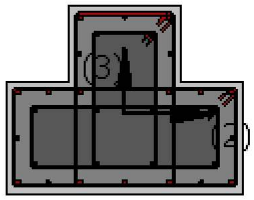
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, Ma = -5.5401E+008
Shear Force, Va = 3.11526
EDGE -B-
Bending Moment, Mb = 4.5517E+008
Shear Force, Vb = -3.11526
BOTH EDGES
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3191.858
-Compression: Aslc = 3499.734
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2475.575
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.72727

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 734492.961
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 918116.201
VCol = 918116.201
knl = 1.00
displacement_ductility_demand = 0.51126198

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 5.5401E+008
Vu = 3.11526
d = 0.8*h = 600.00
Nu = 5.0716E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 828294.726
where:
Vs,jacket = Vs,j1 + Vs,j2 = 753982.237
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 282743.339 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 74312.489
Vs,c1 = 74312.489 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00

Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 570961.316
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00644858
θy = (My*Ls/3)/EIeff = 0.01261306 ((4.29),Biskinis Phd))
My = 1.9034E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.3868598E-006
with fy = 601.9953
d = 707.00
ξy = 0.42365327
A = 0.02250607
B = 0.01848214
with pt = 0.00368581
pc = 0.00229194
pv = 0.00398517
N = 5.0716E+006
b = 950.00
δ'' = 0.06082037
Φy_comp = 4.5684036E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.50306838
A = -0.01327296
B = 0.00593898
with Es = 200000.00
CONFIRMATION: ξy = 0.50306838 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 4

column C1, Floor 1

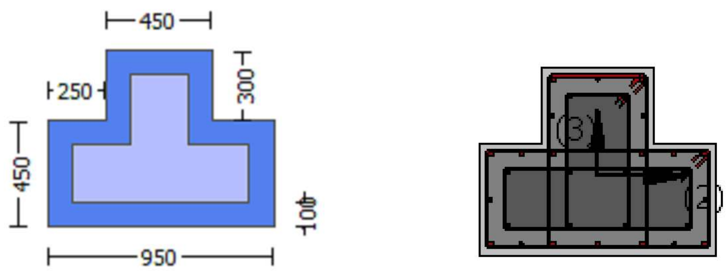
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)



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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00

Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-
Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006

fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied

--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
 - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
 - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
 b = 450.00
 d = 707.00
 d' = 43.00
 v = 0.88729156
  N = 5.0813E+006
 fc = 18.00
 εco (5A.5, TBDY) = 0.002
 Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
  The Shear_factor is considered equal to 1 (pure moment strength)
  From (5.4b), TBDY: εcu = 0.01486841
  ωwe (5.4c) = 0.08077545
   ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
    ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
    The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
    of the rectangular sections confinement, which is expressed by (5.4d).
    The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
    "Theoretical Stress-Strain Model for Confined Concrete."
    J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
    Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
      is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
    Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->

Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307

λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:

d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006
EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741

N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->

v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied

--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

---

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

---

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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

$\varepsilon suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352

εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006

Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00

Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.9854E+009
Shear Force, V2 = -716139.537
Shear Force, V3 = 3.11526
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3191.858
-Compression: Aslc = 3499.734
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00263779
θu = θy + θp = 0.00329724

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00329724 ((4.29),Biskinis Phd))
My = 1.6308E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2772.431
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3767581E-006
with fy = 601.9953
d = 907.00
ξy = 0.47957772
A = 0.0370359
B = 0.02922707
with pt = 0.0037716

pc = 0.0037716
pv = 0.00885172
N = 5.0716E+006
b = 450.00
δ'' = 0.04740904
Φy_comp = 2.6024973E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.68835635
A = -0.02184193
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.44711
d = d_external = 907.00
s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00427788
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00357443
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00070345
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 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 = 5.0716E+006
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 608.5561
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
b = 450.00
d = 907.00
f'cE = 15.20

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

Calculation No. 5

column C1, Floor 1

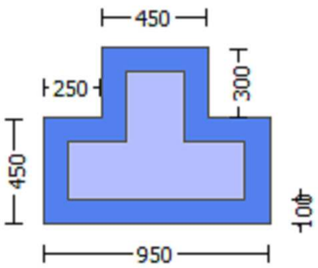
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

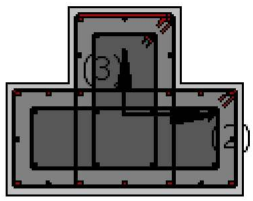
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
###

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.9854E+009
Shear Force, Va = -716139.537
EDGE -B-
Bending Moment, Mb = -3.5795E+008
Shear Force, Vb = 716139.537
BOTH EDGES
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 1.2116E+006
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 1.5146E+006
VCol = 1.5146E+006
knl = 1.00
displacement_ductility_demand = 1.56089

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.5795E+008
Vu = 716139.537
d = 0.8*h = 760.00
Nu = 5.0716E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 980981.156
where:
Vs,jacket = Vs,j1 + Vs,j2 = 879645.943
Vs,j1 = 282743.339 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778

Vs,j2 = 596902.604 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 101335.213
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 101335.213 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 723217.666
bw = 450.00

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00092788
θy = (My*Ls/3)/EIeff = 0.00059446 ((4.29),Biskinis Phd))
My = 1.6308E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 499.8385
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3767581E-006
with fy = 601.9953
d = 907.00
ξy = 0.47957772
A = 0.0370359
B = 0.02922707
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0716E+006
b = 450.00
δ'' = 0.04740904
Φy_comp = 2.6024973E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.68835635

A = -0.02184193
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 6

column C1, Floor 1

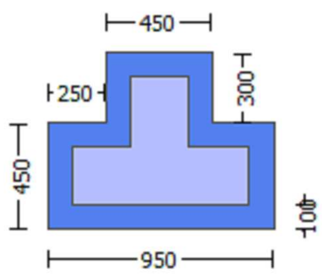
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

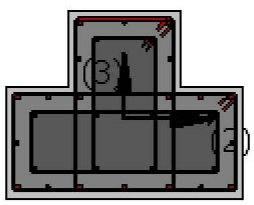
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-
Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----

Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25

fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813

MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->

New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411

Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006
EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00

fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658

Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->

ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected

--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00

New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 4.5517E+008
Shear Force, V2 = 716139.537
Shear Force, V3 = -3.11526
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00988092
θu = θy + θp = 0.01235115

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01235115 ((4.29),Biskinis Phd))
My = 1.8639E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.1326140E-006
with fy = 601.9953
d = 707.00
ξy = 0.40310908
A = 0.02250607
B = 0.01717304
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 5.0716E+006
b = 950.00
δ" = 0.06082037
Φy_comp = 4.9351105E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.46568752
A = -0.01327296
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.46568752 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.92314
d = d_external = 707.00
s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.0035764
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00301593
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00056047
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 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 = 5.0716E+006
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 609.3286
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292

b = 950.00
d = 707.00
f'cE = 15.20

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

Calculation No. 7

column C1, Floor 1

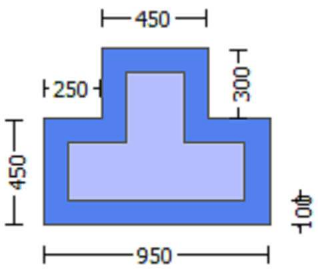
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

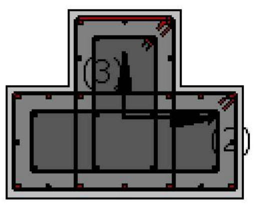
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column

Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -5.5401E+008
Shear Force, Va = 3.11526
EDGE -B-
Bending Moment, Mb = 4.5517E+008
Shear Force, Vb = -3.11526
BOTH EDGES
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 734492.961
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 918116.201
VCol = 918116.201
knl = 1.00
displacement_ductility_demand = 0.14955718

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00

Mu = 4.5517E+008
Vu = 3.11526
d = 0.8*h = 600.00
Nu = 5.0716E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 828294.726
where:
Vs,jacket = Vs,j1 + Vs,j2 = 753982.237
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 282743.339 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 74312.489
Vs,c1 = 74312.489 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 570961.316
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.0018472
θy = (My*Ls/3)/EIeff = 0.01235115 ((4.29),Biskinis Phd))
My = 1.8639E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

web width, bw = 450.00
flange thickness, t = 450.00

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.1326140E-006
with fy = 601.9953
d = 707.00
ξy = 0.40310908
A = 0.02250607
B = 0.01717304
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 5.0716E+006
b = 950.00
δ" = 0.06082037
Φy_comp = 4.9351105E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.46568752
A = -0.01327296
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.46568752 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 8

column C1, Floor 1

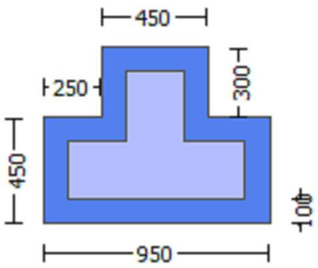
Limit State: Operational Level (data interpolation between analysis steps 33 and 34)

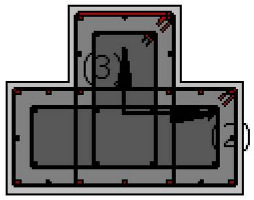
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-

Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025

εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied

--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, $\rho 1$, $\rho 2$, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
$\xi^* cu$ (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
$\varphi u = \varphi cu$ (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->

v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009

----

with full section properties:
   b = 450.00
   d = 707.00
   d' = 43.00
   v = 0.88729156
      N = 5.0813E+006
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
      The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00

s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00

Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006

EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->

v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25

fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
  - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
  - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
  - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
  b = 450.00
  d = 907.00
  d' = 43.00
  v = 0.69163741
    N = 5.0813E+006
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633

fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:

d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -3.5795E+008
Shear Force, V2 = 716139.537
Shear Force, V3 = -3.11526
Axial Force, F = -5.0716E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38

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

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00047556
θu = θy + θp = 0.00059446

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00059446 ((4.29),Biskinis Phd))
My = 1.6308E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 499.8385
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0716E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3767581E-006
with fy = 601.9953
d = 907.00
ξy = 0.47957772
A = 0.0370359
B = 0.02922707
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0716E+006
b = 450.00
δ'' = 0.04740904
Φy_comp = 2.6024973E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.68835635
A = -0.02184193
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 1.44711
  d = d_external = 907.00
  s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00427788
  jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00357443
    Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
    Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
    s1 = 100.00
  core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00070345
    Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
    Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
    s2 = 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 = 5.0716E+006
  Ag = 562500.00
  f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
  fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
  fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 608.5561
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
  b = 450.00
  d = 907.00
  f'cE = 15.20

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

Calculation No. 9

column C1, Floor 1

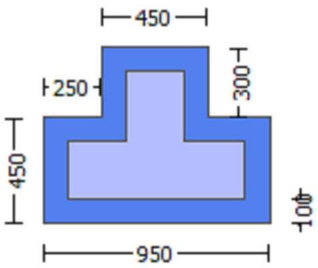
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

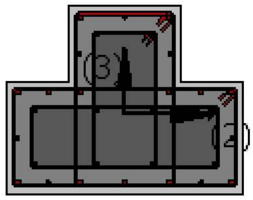
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, Ma = -1.8918E+009
Shear Force, Va = -638013.908
EDGE -B-
Bending Moment, Mb = -3.3682E+008
Shear Force, Vb = 638013.908
BOTH EDGES
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3345.796
-Compression: Aslc = 3345.796
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 639759.811
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 799699.764
VCol = 1.1287E+006
knl = 0.70851738
displacement_ductility_demand = 5.88643

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 3.90154
Mu = 1.8918E+009
Vu = 638013.908
d = 0.8*h = 760.00
Nu = 5.0666E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 980981.156
where:
Vs,jacket = Vs,j1 + Vs,j2 = 879645.943
Vs,j1 = 282743.339 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 596902.604 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 101335.213
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 101335.213 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 420.00
s = 250.00

Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 723217.666
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.02075981
θy = (My*Ls/3)/EIeff = 0.00352672 ((4.29),Biskinis Phd))
My = 1.6309E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2965.168
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3752290E-006
with fy = 601.9953
d = 907.00
ξy = 0.4794529
A = 0.03701556
B = 0.02920673
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0666E+006
b = 450.00
δ" = 0.04740904
Φy_comp = 2.6045948E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.687802
A = -0.02180425
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 10

column C1, Floor 1

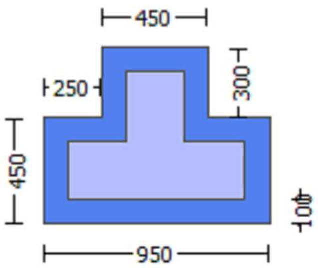
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

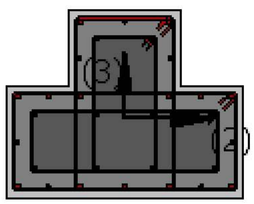
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00

Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-
Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone

--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593

Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00

s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00

s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00

Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006
EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu^* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to $\Sigma bi2/6$ as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to $\Sigma bi2/6$ as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
$\varepsilon y1$ = 0.0025
$\varepsilon sh1$ = 0.008
ft1 = 907.50
fy1 = 756.25
$\varepsilon su1$ = 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.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264

MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->

New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3

MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633

fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member

Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -6.3339E+008
Shear Force, V2 = -638013.908
Shear Force, V3 = 2.2058
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3345.796
-Compression: Aslc = 3345.796
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01920821
θu = θy + θp = 0.02401027

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01234946 ((4.29),Biskinis Phd))
My = 1.8636E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.1312074E-006
with fy = 601.9953
d = 707.00
ξy = 0.40299134
A = 0.02249371

B = 0.01716068
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 5.0666E+006
b = 950.00
δ" = 0.06082037
Φy_comp = 4.9385210E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.46536593
A = -0.01325006
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.46536593 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.01166081
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.92314
d = d_external = 707.00
s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.0035764
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00301593
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00056047
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 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 = 5.0666E+006
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 609.3286
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292
b = 950.00
d = 707.00
f'cE = 15.20

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

Calculation No. 11

column C1, Floor 1

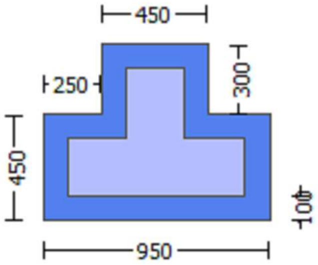
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

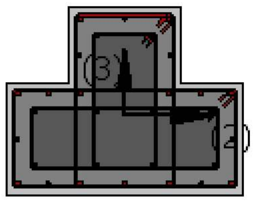
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
##

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -6.3339E+008
Shear Force, Va = 2.2058
EDGE -B-
Bending Moment, Mb = 4.5511E+008
Shear Force, Vb = -2.2058
BOTH EDGES
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3345.796
-Compression: Aslc = 3345.796
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 734369.173
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 917961.466
VCol = 917961.466
knl = 1.00
displacement_ductility_demand = 0.9445196

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 6.3339E+008
Vu = 2.2058
d = 0.8*h = 600.00
Nu = 5.0666E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 828294.726
where:
Vs,jacket = Vs,j1 + Vs,j2 = 753982.237
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667

Vs,j2 = 282743.339 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 74312.489
Vs,c1 = 74312.489 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 570961.316
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.0116643
θy = (My*Ls/3)/Eleff = 0.01234946 ((4.29),Biskinis Phd))
My = 1.8636E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.1312074E-006
with fy = 601.9953
d = 707.00
ξy = 0.40299134
A = 0.02249371
B = 0.01716068
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 5.0666E+006
b = 950.00

δ" = 0.06082037
Φy_comp = 4.9385210E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.46536593
A = -0.01325006
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.46536593 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 12

column C1, Floor 1

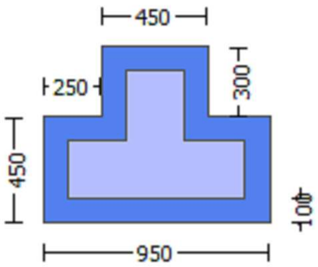
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

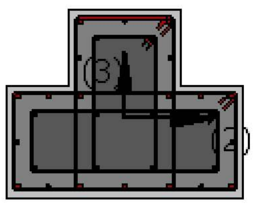
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





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

Constant Properties

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

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-
Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009

Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352

εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00

d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)

--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
   b = 950.00
   d = 707.00
   d' = 43.00
   v = 0.420296
      N = 5.0813E+006
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.01486841
      ωwe (5.4c) = 0.08077545
         ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
            ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
            The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
            of the rectangular sections confinement, which is expressed by (5.4d).
            The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
            "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->

v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005

Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80

Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006
EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345

Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00

fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:

b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover

δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009

---

with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel

--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->

φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.8918E+009
Shear Force, V2 = -638013.908
Shear Force, V3 = 2.2058
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 3345.796
-Compression: Aslc = 3345.796
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01309245
θu = θy + θp = 0.01636556

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00352672 ((4.29),Biskinis Phd))
My = 1.6309E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 2965.168
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014

factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3752290E-006
with fy = 601.9953
d = 907.00
ξy = 0.4794529
A = 0.03701556
B = 0.02920673
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0666E+006
b = 450.00
δ'' = 0.04740904
Φy_comp = 2.6045948E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.687802
A = -0.02180425
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.01283884
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.44711
d = d_external = 907.00
s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00427788
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00357443
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00070345
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 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 = 5.0666E+006
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 608.5561
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493

b = 450.00
d = 907.00
f'cE = 15.20

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

Calculation No. 13

column C1, Floor 1

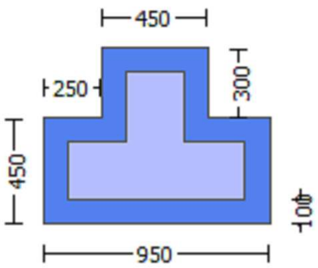
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

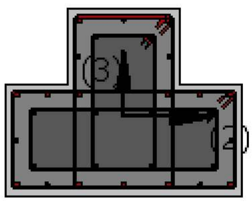
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column

Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.8918E+009
Shear Force, Va = -638013.908
EDGE -B-
Bending Moment, Mb = -3.3682E+008
Shear Force, Vb = 638013.908
BOTH EDGES
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 1.2114E+006
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 1.5142E+006
VCol = 1.5142E+006
knl = 1.00
displacement_ductility_demand = 1.40424

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00

Mu = 3.3682E+008
Vu = 638013.908
d = 0.8*h = 760.00
Nu = 5.0666E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 980981.156
where:
Vs,jacket = Vs,j1 + Vs,j2 = 879645.943
Vs,j1 = 282743.339 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 596902.604 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 101335.213
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 101335.213 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 723217.666
bw = 450.00

---

displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00088171
θy = (My*Ls/3)/EIeff = 0.0006279 ((4.29),Biskinis Phd))
My = 1.6309E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 527.9175
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3752290E-006

with fy = 601.9953
d = 907.00
ξy = 0.4794529
A = 0.03701556
B = 0.02920673
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0666E+006
b = 450.00
δ'' = 0.04740904
Φy_comp = 2.6045948E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.687802
A = -0.02180425
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 14

column C1, Floor 1

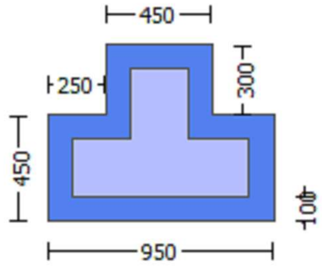
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

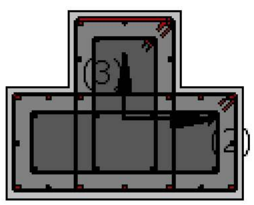
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-
Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314

Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25

fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
   b = 950.00
   d = 707.00
   d' = 43.00
   v = 0.420296
      N = 5.0813E+006
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone

--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.8236E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00

s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
###
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006
EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25

fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264

MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->

New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.7267E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965

fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 4.5511E+008
Shear Force, V2 = 638013.908
Shear Force, V3 = -2.2058
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1859.823
-Middle: Asl,mid,jacket = 2060.885
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 615.7522
-Middle: Asl,mid,core = 615.7522
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01920821 θu = θy + θp = 0.02401027

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01234946 ((4.29),Biskinis Phd))
My = 1.8636E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.1312074E-006
with fy = 601.9953
d = 707.00
ξy = 0.40299134
A = 0.02249371
B = 0.01716068
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 5.0666E+006
b = 950.00
δ'' = 0.06082037
Φy_comp = 4.9385210E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.46536593
A = -0.01325006
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.46536593 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.01166081
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.92314
d = d_external = 707.00
s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.0035764
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00301593
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00

core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00056047
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 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 = 5.0666E+006
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 609.3286
pl = Area_Tot_Long_Rein/(b*d) = 0.00996292
b = 950.00
d = 707.00
f'cE = 15.20

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

Calculation No. 15

column C1, Floor 1

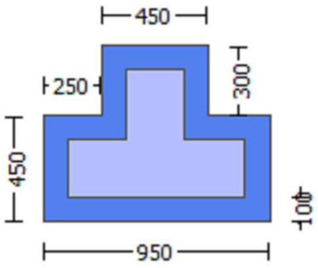
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

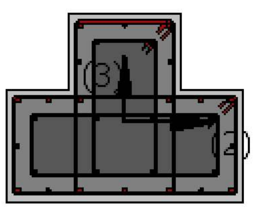
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





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

Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, κ = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 8.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00
Concrete Elasticity, Ec = 16281.278
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 = 18.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
Existing material: Concrete Strength, fc = fcm = 12.00
Existing material: Steel Strength, fs = fsm = 525.00
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -6.3339E+008
Shear Force, Va = 2.2058
EDGE -B-
Bending Moment, Mb = 4.5511E+008
Shear Force, Vb = -2.2058
BOTH EDGES
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637
Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 734369.173
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 917961.466
VCol = 917961.466
knl = 1.00
displacement_ductility_demand = 0.15701928

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 = 10.13333, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5511E+008
Vu = 2.2058
d = 0.8*h = 600.00
Nu = 5.0666E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 828294.726
where:
Vs,jacket = Vs,j1 + Vs,j2 = 753982.237
Vs,j1 = 471238.898 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 282743.339 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 500.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 74312.489
Vs,c1 = 74312.489 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 420.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 570961.316
bw = 450.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.0019391
θy = (My*Ls/3)/Eleff = 0.01234946 ((4.29),Biskinis Phd))
My = 1.8636E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 6000.00

From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.0181E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.3116E+014

Calculation of Yielding Moment My

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

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.1312074E-006
with fy = 601.9953
d = 707.00
ξy = 0.40299134
A = 0.02249371
B = 0.01716068
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 5.0666E+006
b = 950.00
δ'' = 0.06082037
Φy_comp = 4.9385210E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.46536593
A = -0.01325006
B = 0.00462988
with Es = 200000.00
CONFIRMATION: ξy = 0.46536593 < t/d

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

Calculation No. 16

column C1, Floor 1

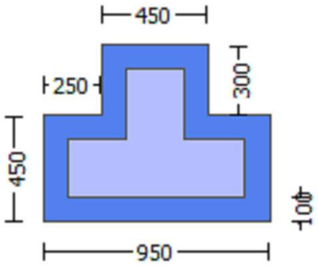
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

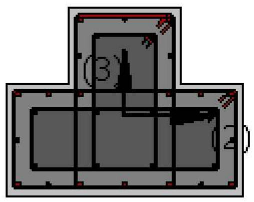
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member
Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -1.7986448E-005
EDGE -B-
Shear Force, Vb = 1.7986448E-005
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 2475.575
-Middle: Asl,mid = 2676.637

Calculation of Shear Capacity ratio , Ve/Vr = 1.92314
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 2.0922E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 3.1383E+009
Mu1+ = 3.1383E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.6290E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 3.1383E+009
Mu2+ = 3.1383E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.6290E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586

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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->

Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
  b = 450.00
  d = 707.00
  d' = 43.00
  v = 0.88729156
    N = 5.0813E+006
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: εcu = 0.01486841
    ωwe (5.4c) = 0.08077545
      ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
        ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
        The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
        of the rectangular sections confinement, which is expressed by (5.4d).
        The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
        "Theoretical Stress-Strain Model for Confined Concrete."
        J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
        Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
            is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
        Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
            is calculated by reducing all the dimensions of the area Aconf,max1 by a length
            equal to half the clear spacing between external hoops.
        AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
      ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
        The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
        of the rectangular sections confinement, which is expressed by (5.4d).
        The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
        "Theoretical Stress-Strain Model for Confined Concrete."
        J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
        Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941

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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009

--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

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 = 1.9524665E-005
Mu = 3.1383E+009
----
with full section properties:
b = 950.00
d = 707.00
d' = 43.00
v = 0.420296
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 900.1904
fy2 = 750.1586
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 = 750.1586
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.09629324
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15360794
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.16660079

and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.10733965
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.17122928
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.18571261
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.42075151
MRc (4.17) = 2.3432E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.47003883
MRo (4.18) = 3.1383E+009
--->
φu = φcu (4.2) = 1.9524665E-005
Mu = MRo

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 = 1.0952761E-005
Mu = 1.6290E+009
----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.88729156
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025

εsh1 = 0.008
ft1 = 900.1904
fy1 = 750.1586
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 = 750.1586
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 902.993
fyv = 752.4941
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 = 752.4941
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.32428344
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.20328574
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.35171278
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.39075399
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.24495458
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42380571
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied

--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.82478813
MRc (4.17) = 1.5333E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
  - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
  - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
  - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.83790293
MRo (4.18) = 1.6290E+009
--->
φu = φcu (4.2) = 1.0952761E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0879E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.0879E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 1.0879E+006
  knl = 1 (zero step-static loading)

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

  λ = 1 (normal-weight concrete)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 4.00
    Mu = 4.8236E+008
    Vu = 1.7986448E-005
  d = 0.8*h = 600.00
  Nu = 5.0813E+006
  Ag = 337500.00
  From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006

where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.0879E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0879E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 4.5550E+008
Vu = 1.7986448E-005
d = 0.8*h = 600.00
Nu = 5.0813E+006
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.0354E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 942477.796
Vs,j1 = 589048.623 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 353429.174 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00

s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 92890.612
Vs,c1 = 92890.612 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 699281.943
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
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 = 656.25
##
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.42131
Element Length, L = 3000.00
Primary Member

Ribbed 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)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -5.5168185E-006
EDGE -B-
Shear Force, Vb = 5.5168185E-006
BOTH EDGES
Axial Force, F = -5.0813E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832

Calculation of Shear Capacity ratio , Ve/Vr = 1.44711
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.9243E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.8865E+009
Mu1+ = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 2.8865E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 2.8865E+009
Mu2+ = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 2.8865E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

---

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

---

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50

fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu

```
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo
-------------------------------------------------------------

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 = 9.9083764E-006
Mu = 2.8865E+009
----------------------------------------------------------------------------
with full section properties:
  b = 450.00
  d = 907.00
  d' = 43.00
  v = 0.69163741
     N = 5.0813E+006
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.01486841
     ωwe (5.4c) = 0.08077545
        ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
           ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
           The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
           of the rectangular sections confinement, which is expressed by (5.4d).
           The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
           "Theoretical Stress-Strain Model for Confined Concrete."
           J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
           Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
                      is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
           Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
                      is calculated by reducing all the dimensions of the area Aconf,max1 by a length
                      equal to half the clear spacing between external hoops.
           AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
        ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
           The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
           of the rectangular sections confinement, which is expressed by (5.4d).
           The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
           "Theoretical Stress-Strain Model for Confined Concrete."
           J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
```

Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724

---

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

---

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522

fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649

MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131
εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

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 = 9.9083764E-006
Mu = 2.8865E+009
----
with full section properties:
b = 450.00
d = 907.00
d' = 43.00
v = 0.69163741
N = 5.0813E+006
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01486841
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01486841
ωwe (5.4c) = 0.08077545
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max1 = 464100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the external perimeter hoops.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to Σbi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max2 = 252164.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.
Aconf,min2 = 111441.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max2 by a length
equal to half the clear spacing between internal hoops.
AnoConf2 = 110709.333 is the unconfined internal core area which is equal to Σbi2/6 as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.724
----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.724
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548
----
psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.25416
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 656.25
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00621307
λc = confinement factor = 1.42131

εy1 = 0.0025
εsh1 = 0.008
ft1 = 907.50
fy1 = 756.25
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 = 756.25
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 907.50
fy2 = 756.25
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 = 756.25
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 899.1522
fyv = 749.2935
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 = 749.2935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.15845977
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.15845977
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.36847443
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 25.58352
εcc (5A.5, TBDY) = 0.00621307
λc = confinement factor = 1.42131
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.18909264
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18909264
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43970658
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->

v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.6344264
MRc (4.17) = 2.3433E+009
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
 - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
 - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.71499649
MRo (4.18) = 2.8865E+009
--->
φu = φcu (4.2) = 9.9083764E-006
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.3298E+006

Calculation of Shear Strength at edge 1, Vr1 = 1.3298E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
 VCol0 = 1.3298E+006
 knl = 1 (zero step-static loading)

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

 λ = 1 (normal-weight concrete)
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 4.00
 Mu = 1.7267E+008
 Vu = 5.5168185E-006
 d = 0.8*h = 760.00
 Nu = 5.0813E+006
 Ag = 427500.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 1.3298E+006
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.3298E+006
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.6609E+008
Vu = 5.5168185E-006
d = 0.8*h = 760.00
Nu = 5.0813E+006
Ag = 427500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 1.2262E+006
where:
Vs,jacket = Vs,j1 + Vs,j2 = 1.0996E+006
Vs,j1 = 353429.174 is calculated for section web jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs,j1 is multiplied by αCol,j1 = 1.00
s/d = 0.27777778
Vs,j2 = 746128.255 is calculated for section flange jacket, with:
d = 760.00
Av = 157079.633

fy = 625.00
s = 100.00
Vs,j2 is multiplied by αCol,j2 = 1.00
s/d = 0.13157895
Vs,core = Vs,c1 + Vs,c2 = 126669.016
Vs,c1 = 0.00 is calculated for section web core, with:
d = 200.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c1 is multiplied by αCol,c1 = 0.00
s/d = 1.25
Vs,c2 = 126669.016 is calculated for section flange core, with:
d = 600.00
Av = 100530.965
fy = 525.00
s = 250.00
Vs,c2 is multiplied by αCol,c2 = 1.00
s/d = 0.41666667
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 885757.128
bw = 450.00

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

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

Constant Properties

Knowledge Factor, κ = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 18.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 12.00
Existing material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 16281.278
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
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)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -3.3682E+008
Shear Force, V2 = 638013.908
Shear Force, V3 = -2.2058
Axial Force, F = -5.0666E+006
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 314.1593
-Compression: Aslc = 6377.433
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1539.38
-Compression: Asl,com = 1539.38
-Middle: Asl,mid = 3612.832
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,jacket = 1231.504
-Compression: Asl,com,jacket = 1231.504
-Middle: Asl,mid,jacket = 2689.203
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten,core = 307.8761
-Compression: Asl,com,core = 307.8761
-Middle: Asl,mid,core = 923.6282
Mean Diameter of Tension Reinforcement, DbL = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01077339
θu = θy + θp = 0.01346674

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.0006279 ((4.29),Biskinis Phd))
My = 1.6309E+009
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 527.9175
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 4.5707E+014
factor = 0.70
Ag = 562500.00
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 15.20
N = 5.0666E+006
Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 6.5295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 6.3752290E-006
with fy = 601.9953
d = 907.00
ξy = 0.4794529
A = 0.03701556
B = 0.02920673
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 5.0666E+006
b = 450.00
δ'' = 0.04740904
Φy_comp = 2.6045948E-006
with fc = 18.00
Ec = 19940.411
ξy = 0.687802
A = -0.02180425

B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.01283884
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.44711
d = d_external = 907.00
s = s_external = 100.00
- ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00427788
jacket: ρs1 = Av1*Lstir1/(s1*Ag) = 0.00357443
Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction
Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction
s1 = 100.00
core: ρs2 = Av2*Lstir2/(s2*Ag) = 0.00070345
Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction
Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction
s2 = 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 = 5.0666E+006
Ag = 562500.00
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 15.20
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 601.9953
fytE = (fy_ext_Trans_Reinf*ρs1+fy_int_Trans_Reinf*ρs2)/(ρs1+ρs2) = 608.5561
pl = Area_Tot_Long_Rein/(b*d) = 0.01639493
b = 450.00
d = 907.00
f'cE = 15.20

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