Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

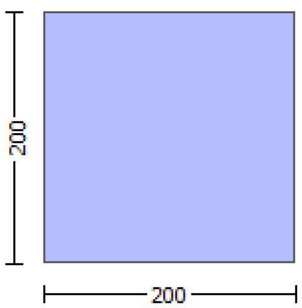
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

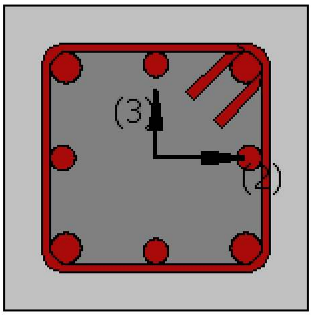
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411

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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
##
Section Height, H = 200.00
Section Width, W = 200.00
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 = 3.1294E+007
Shear Force, Va = -0.03434455
EDGE -B-
Bending Moment, Mb = -1.2151E+007
Shear Force, Vb = 0.03434455
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 42967.874
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 42967.874
VCol = 42967.874
knl = 1.00
displacement_ductility_demand = 0.33122636

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)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.1294E+007
Vu = 0.03434455
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
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 = 0.01502031
θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.02575716
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

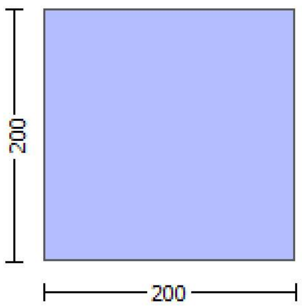
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

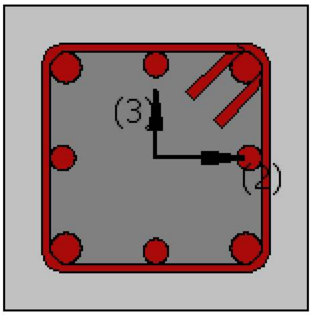
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00

d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00

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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->

φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
---------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 161.00
  d' = 39.00
  v = 0.73326916
     N = 425002.803
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.006331
     ωwe (5.4c) = 0.00500911
        ase ((5.4d), TBDY) = 0.07653356
           bo = 144.00
           ho = 144.00
           Σbi2 = 82944.00
        psh,min = Min(psh,x , psh,y) = 0.00188496
     --------------------------------------------------------------------
        psh,x (5.4d) = 0.00188496
           Ash = Astir*ns = 28.27433
              No stirups, ns = 2.00
           bk = 200.00
     --------------------------------------------------------------------
        psh,y (5.4d) = 0.00188496
           Ash = Astir*ns = 28.27433
              No stirups, ns = 2.00
           bk = 200.00
     --------------------------------------------------------------------
           s = 150.00
```

fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture

δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 90566.489
   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)
   fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 1.4668299E-010
      Vu = 3.3123124E-013
    d = 0.8*h = 160.00

Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00

Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007

----

with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496

----

psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217

and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156

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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.1295E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.4679262E-010
Shear Force, V2 = -0.03434455
Shear Force, V3 = -3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01198086
θu = θy + θp = 0.01198086

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716

pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00064397
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.58749167
d = 161.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
bw = 200.00
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.
NUD = 425002.803
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
b = 200.00
d = 161.00
f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

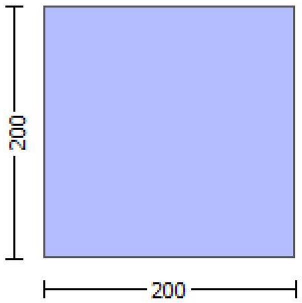
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

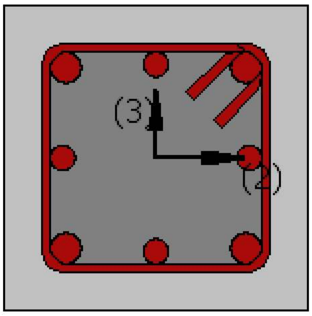
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
###
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.4679262E-010

Shear Force, Va = -3.3113212E-013
EDGE -B-
Bending Moment, Mb = 9.2841507E-010
Shear Force, Vb = 3.3113212E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 79903.891
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 79903.891
VCol = 79903.891
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4679262E-010
Vu = 3.3113212E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.6576781E-019
θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
 with fy = 500.00
 d = 161.00
 ξy = 0.55927095
 A = 0.09040032
 B = 0.06615088
 with pt = 0.02575716
 pc = 0.02575716
 pv = 0.01248832
 N = 425002.803
 b = 200.00
 δ'' = 0.24223602
Φy_comp = 1.4653507E-005
 with fc = 18.00
 Ec = 19940.411
 ξy = 0.6887212
 A = 0.02338683
 B = 0.03975319
 with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

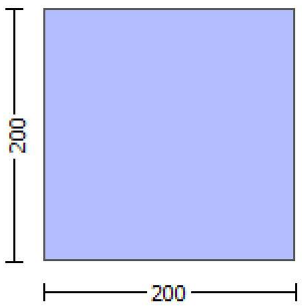
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

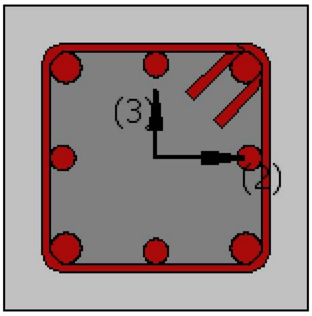
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
------------------------------------------------------------

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 = 5.5526021E-005
Mu = 7.9811E+007
---------------------------------------------------------------------------
with full section properties:
   b = 200.00
   d = 161.00
   d' = 39.00
   v = 0.73326916
      N = 425002.803
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.006331
      ωwe (5.4c) = 0.00500911
         ase ((5.4d), TBDY) = 0.07653356
            bo = 144.00
            ho = 144.00
            Σbi2 = 82944.00
         psh,min = Min(psh,x , psh,y) = 0.00188496
      -------------------------------------------------------------------
         psh,x (5.4d) = 0.00188496
            Ash = Astir*ns = 28.27433
               No stirups, ns = 2.00
            bk = 200.00
```

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00

d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00

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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->

φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES

Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
 b = 200.00
 d = 161.00
 d' = 39.00
 v = 0.73326916
  N = 425002.803
 fc = 18.00
 εco (5A.5, TBDY) = 0.002
 Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
  The Shear_factor is considered equal to 1 (pure moment strength)
  From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Mu2-
-------------------------------------------------------------------------

-------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
-------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 161.00
  d' = 39.00
  v = 0.73326916
    N = 425002.803
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: εcu = 0.006331
    ωwe (5.4c) = 0.00500911
      ase ((5.4d), TBDY) = 0.07653356
        bo = 144.00
        ho = 144.00
        Σbi2 = 82944.00
      psh,min = Min(psh,x , psh,y) = 0.00188496
    -----------------------------------------------------------------
      psh,x (5.4d) = 0.00188496
        Ash = Astir*ns = 28.27433
          No stirups, ns = 2.00
        bk = 200.00
    -----------------------------------------------------------------
      psh,y (5.4d) = 0.00188496
        Ash = Astir*ns = 28.27433
          No stirups, ns = 2.00
        bk = 200.00
    -----------------------------------------------------------------
        s = 150.00
      fywe = 625.00
      fce  = 18.00
    From ((5.A5), TBDY), TBDY: εcc = 0.00232239
      λc  = confinement factor = 1.03224
  εy1 = 0.0025
  εsh1 = 0.008
  ft1 = 750.00
  fy1 = 625.00
  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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.1295E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = 3.1294E+007
Shear Force, V2 = -0.03434455
Shear Force, V3 = -3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.04534758
θu = θy + θp = 0.04534758

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
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 = 1.08468
  d = 161.00
  s = 150.00
  ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
  Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
  bw = 200.00
  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.
    NUD = 425002.803
    Ag = 40000.00
    f'cE = 18.00
    fytE = fylE = 500.00
ρl = Area_Tot_Long_Rein/(b*d) = 0.06400263
  b = 200.00
  d = 161.00
    f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

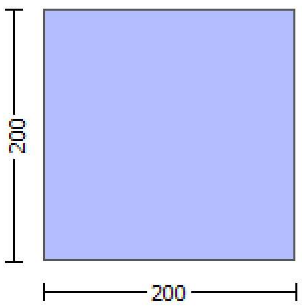
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

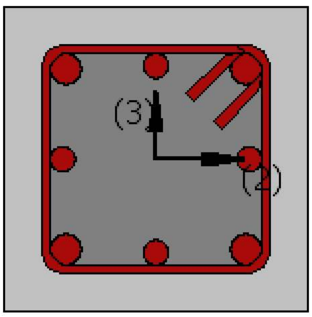
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
##
Section Height, H = 200.00
Section Width, W = 200.00
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 = 3.1294E+007
Shear Force, Va = -0.03434455
EDGE -B-
Bending Moment, Mb = -1.2151E+007
Shear Force, Vb = 0.03434455
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 42967.874
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 42967.874
VCol = 42967.874
knl = 1.00
displacement_ductility_demand = 0.22141237

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)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.03434455
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
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 = 0.01004051
θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.02575716
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

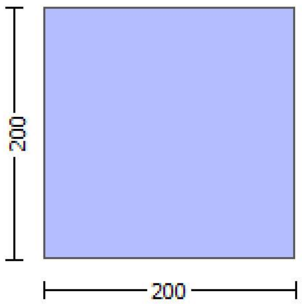
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

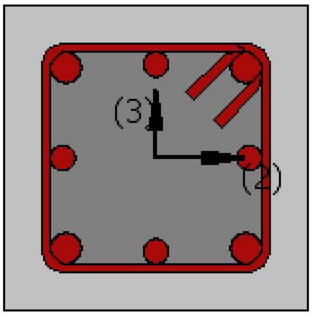
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00

Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00

ω_1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω_2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ω_v = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω_1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω_2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ω_v = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00

v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007

----

with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496

----

psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----

s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
---------------------------------------------------------------------------
with full section properties:
   b = 200.00
   d = 161.00
   d' = 39.00
   v = 0.73326916
      N = 425002.803
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.006331
      ωwe (5.4c) = 0.00500911
         ase ((5.4d), TBDY) = 0.07653356
            bo = 144.00
            ho = 144.00
            Σbi2 = 82944.00
         psh,min = Min(psh,x , psh,y) = 0.00188496
      -------------------------------------------------------------------
         psh,x (5.4d) = 0.00188496
            Ash = Astir*ns = 28.27433
               No stirups, ns = 2.00
            bk = 200.00
      -------------------------------------------------------------------
         psh,y (5.4d) = 0.00188496
            Ash = Astir*ns = 28.27433
               No stirups, ns = 2.00
            bk = 200.00
      -------------------------------------------------------------------
            s = 150.00
         fywe = 625.00
         fce  = 18.00
```

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
   b = 200.00
   d = 161.00
   d' = 39.00
   v = 0.73326916
      N = 425002.803
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.1295E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = 9.2841507E-010
Shear Force, V2 = 0.03434455
Shear Force, V3 = 3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01198086
θu = θy + θp = 0.01198086

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005

with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00064397
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.58749167
d = 161.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
bw = 200.00
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.
NUD = 425002.803
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
b = 200.00
d = 161.00
f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

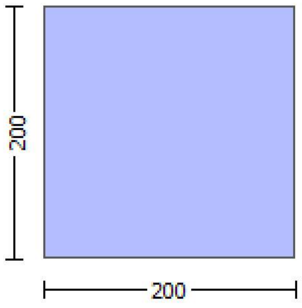
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

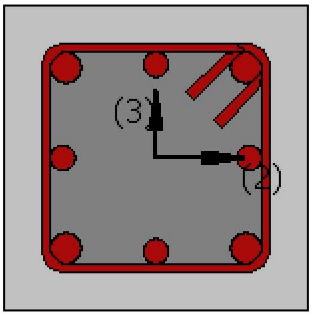
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
##
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.4679262E-010

Shear Force, Va = -3.3113212E-013
EDGE -B-
Bending Moment, Mb = 9.2841507E-010
Shear Force, Vb = 3.3113212E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 79903.891
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 79903.891
VCol = 79903.891
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2841507E-010
Vu = 3.3113212E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.9720104E-019
θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.02575716
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

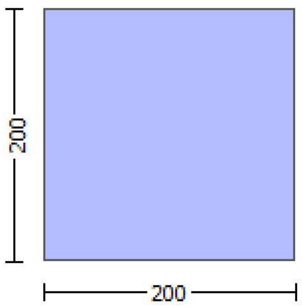
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

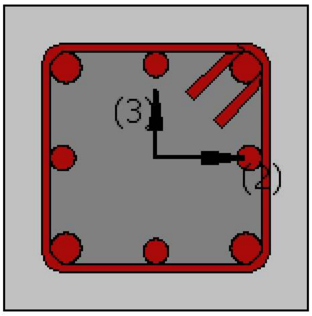
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

  fcc (5A.2, TBDY) = 18.58031
  εcc (5A.5, TBDY) = 0.00232239
      λc = confinement factor = 1.03224
  ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
  ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
  ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007

----

with full section properties:
  b = 200.00

d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00

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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->

φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00

$\varepsilon y2 = 0.0025$
$\varepsilon sh2 = 0.008$
$ft2 = 750.00$
$fy2 = 625.00$
$\varepsilon su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 625.00
with Es2 = Es = 200000.00
$\varepsilon yv = 0.0025$
$\varepsilon shv = 0.008$
$ftv = 750.00$
$fyv = 625.00$
$\varepsilon suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and εyv,εshv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = fs = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES

Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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

$\varepsilon su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and εy2,εsh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
εy1,εsh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = fs = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
--------------------------------------------------------------------------
--------------------------------------------------------------------------
--------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------

--------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
--------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 161.00
  d' = 39.00
  v = 0.73326916
     N = 425002.803
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.006331
     ωwe (5.4c) = 0.00500911
        ase ((5.4d), TBDY) = 0.07653356
           bo = 144.00
           ho = 144.00
           Σbi2 = 82944.00
        psh,min = Min(psh,x , psh,y) = 0.00188496
     ------------------------------------------------------------------
        psh,x (5.4d) = 0.00188496
           Ash = Astir*ns = 28.27433
              No stirups, ns = 2.00
           bk = 200.00
     ------------------------------------------------------------------
        psh,y (5.4d) = 0.00188496
           Ash = Astir*ns = 28.27433
              No stirups, ns = 2.00
           bk = 200.00
     ------------------------------------------------------------------
           s = 150.00
        fywe = 625.00
        fce  = 18.00
     From ((5.A5), TBDY), TBDY: εcc = 0.00232239
        λc  = confinement factor = 1.03224
  εy1 = 0.0025
  εsh1 = 0.008
  ft1 = 750.00
  fy1 = 625.00
  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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 49053.156
   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)
   fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 4.00
      Mu = 3.1295E+007
      Vu = 0.00011663
    d = 0.8*h = 160.00
    Nu = 425002.803
    Ag = 40000.00
    From (11.5.4.8), ACI 318-14: Vs = 7539.822
      Av = 56548.668
      fy = 500.00
      s = 150.00
    Vs is multiplied by αCol = 0.25
      s/d = 0.9375
    Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.2151E+007
Shear Force, V2 = 0.03434455
Shear Force, V3 = 3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.04534758
θu = θy + θp = 0.04534758

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
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 = 1.08468
   d = 161.00
   s = 150.00
   ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
   Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
   bw = 200.00
   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.
     NUD = 425002.803
     Ag = 40000.00
     f'cE = 18.00
     fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
   b = 200.00
   d = 161.00
     f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

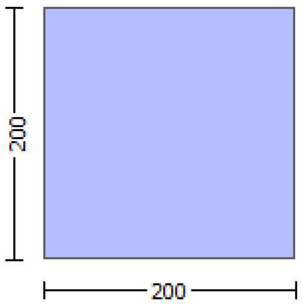
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

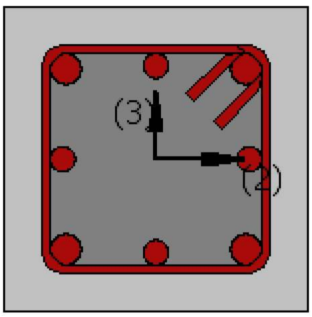
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
###
Section Height, H = 200.00
Section Width, W = 200.00
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 = 3.1294E+007
Shear Force, Va = -0.03434455
EDGE -B-
Bending Moment, Mb = -1.2151E+007
Shear Force, Vb = 0.03434455
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 42967.874
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 42967.874
VCol = 42967.874
knl = 1.00
displacement_ductility_demand = 0.33122636

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)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 3.1294E+007
Vu = 0.03434455
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
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 = 0.01502031
θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.02575716
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

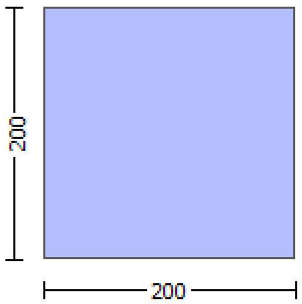
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

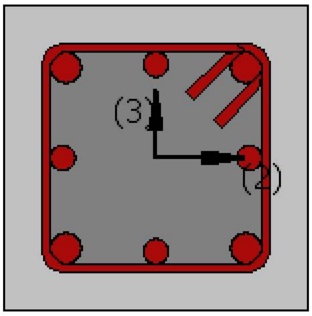
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00

Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00

v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005

Mu = 7.9811E+007

----

with full section properties:

b = 200.00

d = 161.00

d' = 39.00

v = 0.73326916

N = 425002.803

fc = 18.00

εco (5A.5, TBDY) = 0.002

Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331

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

From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911

ase ((5.4d), TBDY) = 0.07653356

bo = 144.00

ho = 144.00

Σbi2 = 82944.00

psh,min = Min(psh,x , psh,y) = 0.00188496

----

psh,x (5.4d) = 0.00188496

Ash = Astir*ns = 28.27433

No stirups, ns = 2.00

bk = 200.00

----

psh,y (5.4d) = 0.00188496

Ash = Astir*ns = 28.27433

No stirups, ns = 2.00

bk = 200.00

----

s = 150.00

fywe = 625.00

fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00232239

λc = confinement factor = 1.03224

εy1 = 0.0025

εsh1 = 0.008

ft1 = 750.00

fy1 = 625.00

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 = 625.00

with Es1 = Es = 200000.00

εy2 = 0.0025

εsh2 = 0.008

ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

```
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------------------


----------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----------------------------------------------------------------------------
with full section properties:
   b = 200.00
   d = 161.00
   d' = 39.00
   v = 0.73326916
       N = 425002.803
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
       The Shear_factor is considered equal to 1 (pure moment strength)
       From (5.4b), TBDY: εcu = 0.006331
```

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.1295E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.4679262E-010
Shear Force, V2 = -0.03434455
Shear Force, V3 = -3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01669165
θu = θy + θp = 0.01669165

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005

with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00535476
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.58749167
d = 161.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
bw = 200.00
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.
NUD = 425002.803
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
b = 200.00
d = 161.00
f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

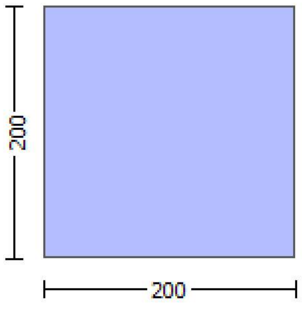
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

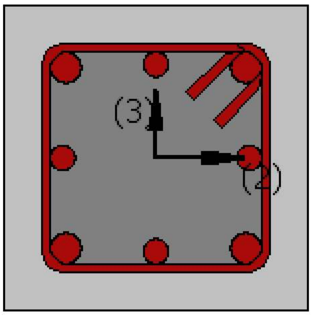
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
###
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.4679262E-010

Shear Force, Va = -3.3113212E-013
EDGE -B-
Bending Moment, Mb = 9.2841507E-010
Shear Force, Vb = 3.3113212E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 79903.891
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 79903.891
VCol = 79903.891
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4679262E-010
Vu = 3.3113212E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.6576781E-019
θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
 with fy = 500.00
 d = 161.00
 ξy = 0.55927095
 A = 0.09040032
 B = 0.06615088
 with pt = 0.02575716
 pc = 0.02575716
 pv = 0.01248832
 N = 425002.803
 b = 200.00
 δ'' = 0.24223602
Φy_comp = 1.4653507E-005
 with fc = 18.00
 Ec = 19940.411
 ξy = 0.6887212
 A = 0.02338683
 B = 0.03975319
 with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

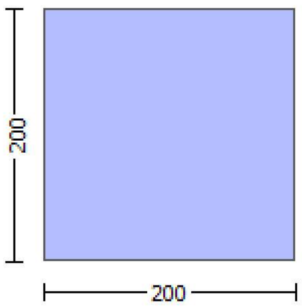
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

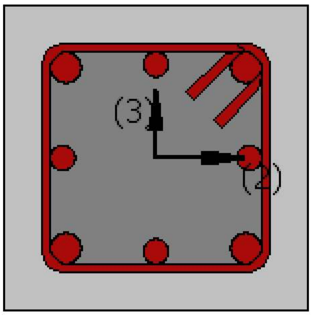
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007

----

with full section properties:
 b = 200.00
 d = 161.00
 d' = 39.00
 v = 0.73326916
 N = 425002.803
 fc = 18.00
 εco (5A.5, TBDY) = 0.002
 Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: εcu = 0.006331
 ωwe (5.4c) = 0.00500911
 ase ((5.4d), TBDY) = 0.07653356
 bo = 144.00
 ho = 144.00
 Σbi2 = 82944.00
 psh,min = Min(psh,x , psh,y) = 0.00188496

----

 psh,x (5.4d) = 0.00188496
 Ash = Astir*ns = 28.27433
 No stirups, ns = 2.00
 bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00

d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00

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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->

φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES

Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 49053.156
   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)
   fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 4.00
      Mu = 3.1295E+007
      Vu = 0.00011663
    d = 0.8*h = 160.00
    Nu = 425002.803
    Ag = 40000.00
    From (11.5.4.8), ACI 318-14: Vs = 7539.822
      Av = 56548.668
      fy = 500.00
      s = 150.00
    Vs is multiplied by αCol = 0.25
      s/d = 0.9375
    Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = 3.1294E+007
Shear Force, V2 = -0.03434455
Shear Force, V3 = -3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 829.3805
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.05070233
θu = θy + θp = 0.05070233

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00535476
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.08468
d = 161.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
bw = 200.00
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.
NUD = 425002.803
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
b = 200.00
d = 161.00
f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

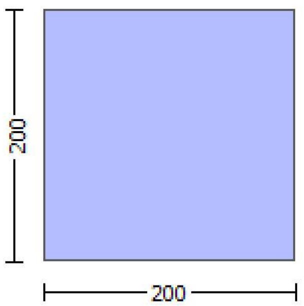
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

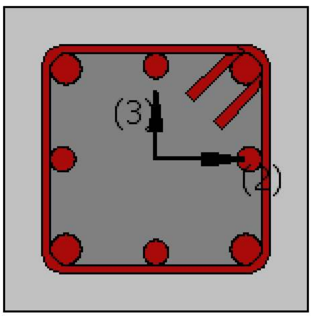
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
###
Section Height, H = 200.00
Section Width, W = 200.00
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 = 3.1294E+007
Shear Force, Va = -0.03434455
EDGE -B-
Bending Moment, Mb = -1.2151E+007
Shear Force, Vb = 0.03434455
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 42967.874
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 42967.874
VCol = 42967.874
knl = 1.00
displacement_ductility_demand = 0.22141237

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)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.03434455
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
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 = 0.01004051
θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.02575716
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

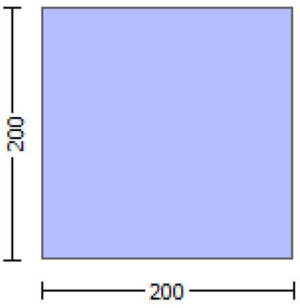
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

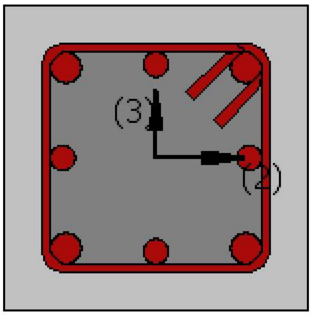
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00

Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00

v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007

----

with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496

----

psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----

s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008

ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2+
--------------------------------------------------------------------------------

--------------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
--------------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 161.00
  d' = 39.00
  v = 0.73326916
     N = 425002.803
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.006331
     ωwe (5.4c) = 0.00500911
        ase ((5.4d), TBDY) = 0.07653356
           bo = 144.00
           ho = 144.00
           Σbi2 = 82944.00
        psh,min = Min(psh,x , psh,y) = 0.00188496
     ------------------------------------------------------------------------
        psh,x (5.4d) = 0.00188496
           Ash = Astir*ns = 28.27433
              No stirups, ns = 2.00
           bk = 200.00
     ------------------------------------------------------------------------
        psh,y (5.4d) = 0.00188496
           Ash = Astir*ns = 28.27433
              No stirups, ns = 2.00
           bk = 200.00
     ------------------------------------------------------------------------
           s = 150.00
        fywe = 625.00
        fce  = 18.00
```

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

```
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) =  5.5526021E-005
Mu = MRc
-----------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------------------


--------------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
--------------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 161.00
  d' = 39.00
  v = 0.73326916
     N = 425002.803
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.006331
```

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 3.1295E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = 9.2841507E-010
Shear Force, V2 = 0.03434455
Shear Force, V3 = 3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.01669165
θu = θy + θp = 0.01669165

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005

with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00535476
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.58749167
d = 161.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
bw = 200.00
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.
NUD = 425002.803
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
b = 200.00
d = 161.00
f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

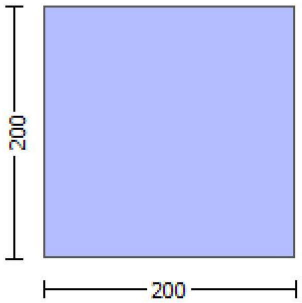
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

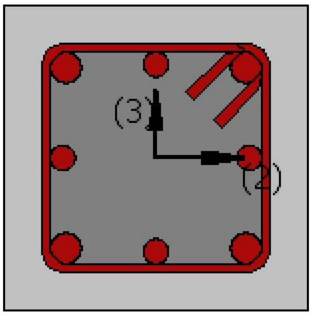
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 12.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 19940.411
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).
Existing material: Concrete Strength, fc = fcm = 18.00
Existing material: Steel Strength, fs = fsm = 500.00
##
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.4679262E-010

Shear Force, Va = -3.3113212E-013
EDGE -B-
Bending Moment, Mb = 9.2841507E-010
Shear Force, Vb = 3.3113212E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 79903.891
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 79903.891
VCol = 79903.891
knl = 1.00
displacement_ductility_demand = 0.00

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

λ = 1 (normal-weight concrete)
fc' = 12.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2841507E-010
Vu = 3.3113212E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 6031.858
Av = 56548.668
fy = 400.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 73638.911
bw = 200.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 1.9720104E-019
θy = (My*Ls/3)/Eleff = 0.01133689 ((4.29),Biskinis Phd))
My = 4.2198E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.02575716
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

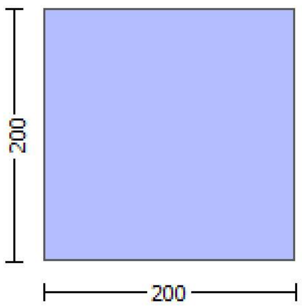
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

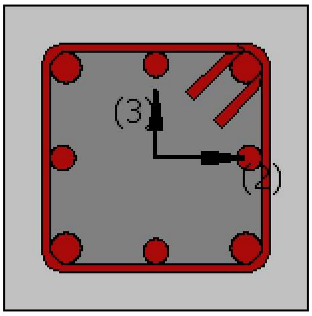
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
###
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -3.3123124E-013
EDGE -B-
Shear Force, Vb = 3.3123124E-013
BOTH EDGES
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 0.58749167
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00

fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00

d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00

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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->

φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00

εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 90566.489

Calculation of Shear Strength at edge 1, Vr1 = 90566.489
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4668299E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 90566.489
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 90566.489
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 9.2860820E-010
Vu = 3.3123124E-013
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
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
Existing material: Steel Strength, fs = 1.25*fsm = 625.00
##
Section Height, H = 200.00
Section Width, W = 200.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.03224
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 = -0.00011663
EDGE -B-
Shear Force, Vb = 0.00011663
BOTH EDGES

Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 1231.504
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239

Calculation of Shear Capacity ratio , Ve/Vr = 1.08468
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 53207.058
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.9811E+007
Mu1+ = 7.9811E+007, 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- = 7.9811E+007, 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-) = 7.9811E+007
Mu2+ = 7.9811E+007, 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- = 7.9811E+007, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->

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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

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 = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331

ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 5.5526021E-005
Mu = 7.9811E+007
----
with full section properties:
b = 200.00
d = 161.00
d' = 39.00
v = 0.73326916
N = 425002.803
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.006331
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.006331
ωwe (5.4c) = 0.00500911
ase ((5.4d), TBDY) = 0.07653356
bo = 144.00
ho = 144.00
Σbi2 = 82944.00
psh,min = Min(psh,x , psh,y) = 0.00188496
----
psh,x (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00188496
Ash = Astir*ns = 28.27433
No stirups, ns = 2.00
bk = 200.00
----
s = 150.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00232239
λc = confinement factor = 1.03224
εy1 = 0.0025
εsh1 = 0.008
ft1 = 750.00
fy1 = 625.00
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 = 625.00
with Es1 = Es = 200000.00
εy2 = 0.0025
εsh2 = 0.008
ft2 = 750.00
fy2 = 625.00
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 = 625.00
with Es2 = Es = 200000.00
εyv = 0.0025
εshv = 0.008
ftv = 750.00
fyv = 625.00
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 = 625.00
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.89434573
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.89434573
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.43362217
and confined core properties:
b = 144.00
d = 133.00
d' = 11.00
fcc (5A.2, TBDY) = 18.58031
εcc (5A.5, TBDY) = 0.00232239
λc = confinement factor = 1.03224
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.50365
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.50365
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.72904313
Case/Assumption: Unconfinesd full section - Steel rupture
δ' does not satisfy Eq. (4.3)
--->
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) = 0.70819045
MRc (4.17) = 7.9811E+007
--->
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) = 0.63294467
MRo (4.18) = 5.9005E+007
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 5.5526021E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 49053.156

Calculation of Shear Strength at edge 1, Vr1 = 49053.156
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 49053.156
   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)
   fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 4.00
      Mu = 3.1295E+007
      Vu = 0.00011663
    d = 0.8*h = 160.00
    Nu = 425002.803
    Ag = 40000.00
    From (11.5.4.8), ACI 318-14: Vs = 7539.822
      Av = 56548.668
      fy = 500.00
      s = 150.00
    Vs is multiplied by αCol = 0.25
      s/d = 0.9375
    Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 49053.156
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 49053.156
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)
fc' = 18.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.2151E+007
Vu = 0.00011663
d = 0.8*h = 160.00
Nu = 425002.803
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 7539.822
Av = 56548.668
fy = 500.00
s = 150.00
Vs is multiplied by αCol = 0.25
s/d = 0.9375
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 90188.879
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, κ = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Primary Member: Concrete Strength, fc = fcm = 18.00
Existing material of Primary Member: Steel Strength, fs = fsm = 500.00
Concrete Elasticity, Ec = 19940.411
Steel Elasticity, Es = 200000.00
Section Height, H = 200.00
Section Width, W = 200.00
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 = -1.2151E+007
Shear Force, V2 = 0.03434455
Shear Force, V3 = 3.3113212E-013
Axial Force, F = -425002.803
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2060.885
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 829.3805
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL = 18.66667

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.05070233
θu = θy + θp = 0.05070233

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04534758 ((4.29),Biskinis Phd))
My = 4.2198E+007
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 = 1.8611E+012
factor = 0.70
Ag = 40000.00
fc' = 18.00
N = 425002.803
Ec*Ig = 2.6587E+012

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 3.5232418E-005
with fy = 500.00
d = 161.00
ξy = 0.55927095
A = 0.09040032
B = 0.06615088
with pt = 0.00188496
pc = 0.02575716
pv = 0.01248832
N = 425002.803
b = 200.00
δ'' = 0.24223602
Φy_comp = 1.4653507E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.6887212
A = 0.02338683
B = 0.03975319
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00535476
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 1.08468
d = 161.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00188496
Av = 56.54867, is the total area of all stirrups parallel to loading (shear) direction
bw = 200.00
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.
NUD = 425002.803
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06400263
b = 200.00
d = 161.00
f'cE = 18.00

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1
At local axis: 3
Integration Section: (b)
