Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

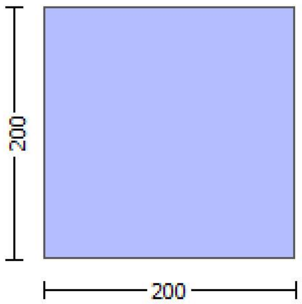
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

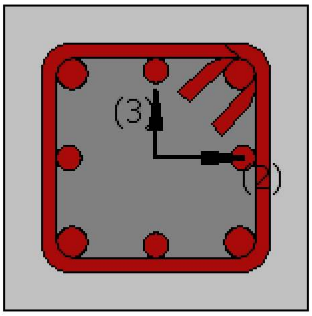
Analysis: Uniform +X

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 = -4.3638E+007
Shear Force, Va = -13868.577
EDGE -B-
Bending Moment, Mb = -6.7584E+006
Shear Force, Vb = 13868.577
BOTH EDGES
Axial Force, F = -141233.232
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 97735.617
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 97735.617
VCol = 97735.617
knl = 1.00
displacement_ductility_demand = 0.49385493

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 = 4.3638E+007
Vu = 13868.577
d = 0.8*h = 160.00
Nu = 141233.232
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 0.02073503
θy = (My*Ls/3)/EIeff = 0.04198608 ((4.29),Biskinis Phd))
My = 4.2163E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3146.553
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141233.232
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448
A = 0.05179231
B = 0.04180463
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

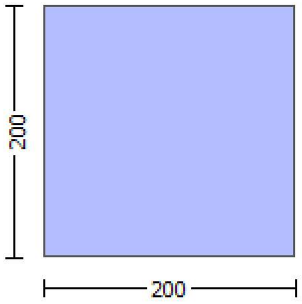
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

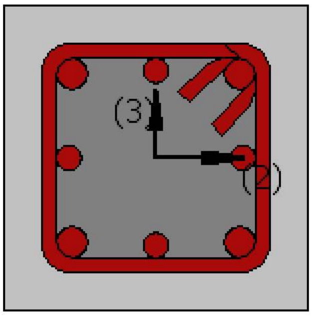
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00

fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00

d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929

λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 145495.182
  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 = 2.0676123E-010
    Vu = 1.4835100E-013
  d = 0.8*h = 160.00
  Nu = 141550.243
  Ag = 40000.00
  From (11.5.4.8), ACI 318-14: Vs = 125663.706
    Av = 157079.633

fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00

Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493

ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 3.0810918E-010
Shear Force, V2 = -13868.577
Shear Force, V3 = 7.3321821E-015
Axial Force, F = -141233.232
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 0.02432778
θu = θy + θp = 0.02432778

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.02001528 ((4.29),Biskinis Phd))
My = 4.2163E+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 = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.00785398
pc = 0.02641339
pv = 0.01280649
N = 141233.232
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448

A = 0.05179231
B = 0.04180463
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.0043125
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.42448768
d = 157.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
Av = 157.0796, 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 = 141233.232
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
b = 200.00
d = 157.00
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

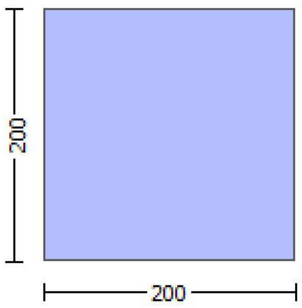
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

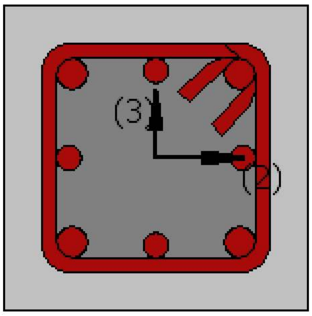
Analysis: Uniform +X

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 = 3.0810918E-010
Shear Force, Va = 7.3321821E-015
EDGE -B-
Bending Moment, Mb = -4.4415813E-011
Shear Force, Vb = -7.3321821E-015
BOTH EDGES
Axial Force, F = -141233.232
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 121832.322
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 121832.322
VCol = 121832.322
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 = 3.0810918E-010
Vu = 7.3321821E-015
d = 0.8*h = 160.00
Nu = 141233.232
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 6.7317641E-019
θy = (My*Ls/3)/EIeff = 0.02001528 ((4.29),Biskinis Phd))
My = 4.2163E+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 = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141233.232

b = 200.00
δ" = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448
A = 0.05179231
B = 0.04180463
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

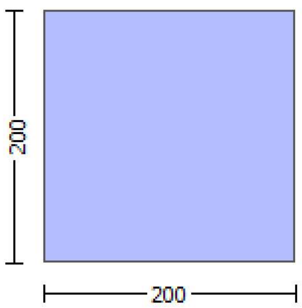
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

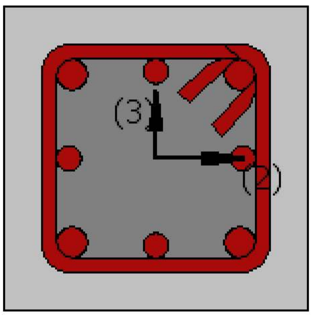
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007

----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732

MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007

----

with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398

----

psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853

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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.0676123E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00

bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00

d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00

d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005

Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -4.3638E+007
Shear Force, V2 = -13868.577
Shear Force, V3 = 7.3321821E-015
Axial Force, F = -141233.232
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 0.04595493
θu = θy + θp = 0.04595493

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04198608 ((4.29),Biskinis Phd))
My = 4.2163E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3146.553
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
 with fy = 500.00
 d = 157.00
 ξy = 0.50819221
 A = 0.07462902
 B = 0.05080038
 with pt = 0.00785398
 pc = 0.02641339
 pv = 0.01280649
 N = 141233.232
 b = 200.00
 δ'' = 0.27388535
Φy_comp = 1.9404180E-005
 with fc = 18.00
 Ec = 19940.411
 ξy = 0.53335448
 A = 0.05179231
 B = 0.04180463
 with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

 - Calculation of θp -

From table 10-8: θp = 0.00396884
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
 shear control ratio VyE/VCol0E = 0.52409919
 d = 157.00
 s = 150.00
 ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
 Av = 157.0796, 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 = 141233.232
 Ag = 40000.00
 f'cE = 18.00
 fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
 b = 200.00
 d = 157.00
 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

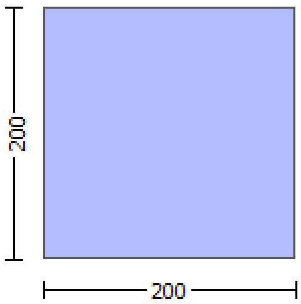
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

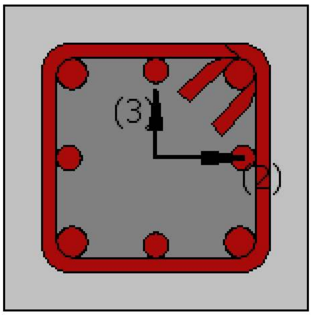
Analysis: Uniform +X

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 = -4.3638E+007
Shear Force, Va = -13868.577
EDGE -B-
Bending Moment, Mb = -6.7584E+006
Shear Force, Vb = 13868.577
BOTH EDGES
Axial Force, F = -141233.232
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 = 105285.243
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 105285.243
VCol = 105285.243
knl = 1.00
displacement_ductility_demand = 0.91605415

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 = 3.04575
Mu = 6.7584E+006
Vu = 13868.577
d = 0.8*h = 160.00
Nu = 141233.232
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 0.0059567
θy = (My*Ls/3)/Eleff = 0.00650256 ((4.29),Biskinis Phd))
My = 4.2163E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 487.32
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00

N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141233.232
b = 200.00
δ" = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448
A = 0.05179231
B = 0.04180463
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

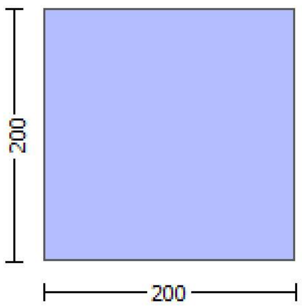
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

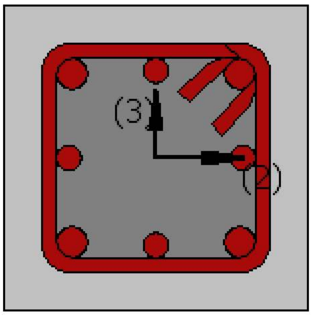
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871

εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00

v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.0676123E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00

psh,min = Min(psh,x , psh,y) = 0.00785398

----

psh,x (5.4d) = 0.00785398

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 200.00

----

psh,y (5.4d) = 0.00785398

Ash = Astir*ns = 78.53982

No stirups, ns = 2.00

bk = 200.00

----

s = 100.00

fywe = 625.00

fce = 18.00

From ((5.A5), TBDY), TBDY: εcc = 0.00514929

λc = confinement factor = 1.31493

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) = 0.91713161

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied

--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
  b = 200.00
  d = 157.00
  d' = 43.00
  v = 0.25044275
    N = 141550.243
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: εcu = 0.01125287
    ωwe (5.4c) = 0.03756688
      ase ((5.4d), TBDY) = 0.1377551
        bo = 140.00
        ho = 140.00
        Σbi2 = 78400.00
      psh,min = Min(psh,x , psh,y) = 0.00785398
    ----
      psh,x (5.4d) = 0.00785398
        Ash = Astir*ns = 78.53982
          No stirups, ns = 2.00
        bk = 200.00
    ----
      psh,y (5.4d) = 0.00785398
        Ash = Astir*ns = 78.53982
          No stirups, ns = 2.00
        bk = 200.00
    ----
        s = 100.00
      fywe = 625.00
      fce = 18.00
    From ((5.A5), TBDY), TBDY: εcc = 0.00514929
      λc = confinement factor = 1.31493
  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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -4.4415813E-011
Shear Force, V2 = 13868.577
Shear Force, V3 = -7.3321821E-015
Axial Force, F = -141233.232
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 = 0.02432778
θu = θy + θp = 0.02432778

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.02001528 ((4.29),Biskinis Phd))
My = 4.2163E+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 = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.00785398
pc = 0.02641339
pv = 0.01280649
N = 141233.232
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448
A = 0.05179231
B = 0.04180463
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.0043125
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 0.42448768
d = 157.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
Av = 157.0796, 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 = 141233.232
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
b = 200.00
d = 157.00
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

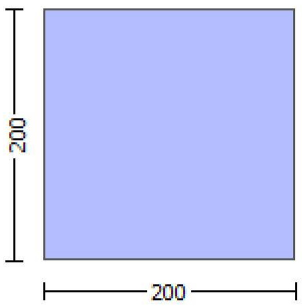
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

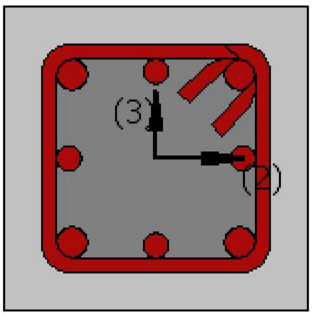
Analysis: Uniform +X

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 = 3.0810918E-010
Shear Force, Va = 7.3321821E-015
EDGE -B-
Bending Moment, Mb = -4.4415813E-011
Shear Force, Vb = -7.3321821E-015
BOTH EDGES
Axial Force, F = -141233.232
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 = 121832.322
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 121832.322
VCol = 121832.322
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 = 4.4415813E-011
Vu = 7.3321821E-015
d = 0.8*h = 160.00
Nu = 141233.232
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633

fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.0077961E-019
θy = (My*Ls/3)/EIeff = 0.02001528 ((4.29),Biskinis Phd))
My = 4.2163E+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 = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141233.232
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448
A = 0.05179231
B = 0.04180463
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

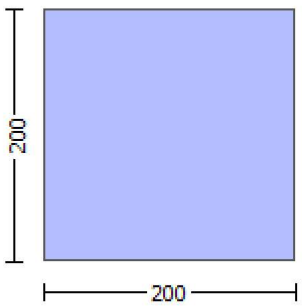
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

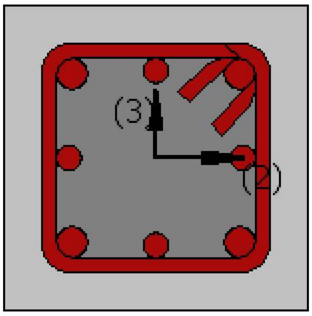
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00

fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00

d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007

----

with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398

----

psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo
-----------------------------------------------------------------

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

---------------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
---------------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 157.00
  d' = 43.00
  v = 0.25044275
     N = 141550.243
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.01125287
     ωwe (5.4c) = 0.03756688
        ase ((5.4d), TBDY) = 0.1377551
           bo = 140.00
           ho = 140.00
           Σbi2 = 78400.00
        psh,min = Min(psh,x , psh,y) = 0.00785398
     -------------------------------------------------------------------------
        psh,x (5.4d) = 0.00785398
           Ash = Astir*ns = 78.53982
              No stirups, ns = 2.00
           bk = 200.00
     -------------------------------------------------------------------------
        psh,y (5.4d) = 0.00785398
           Ash = Astir*ns = 78.53982
              No stirups, ns = 2.00
           bk = 200.00
     -------------------------------------------------------------------------
           s = 100.00
        fywe = 625.00
        fce  = 18.00
     From ((5.A5), TBDY), TBDY: εcc = 0.00514929
```

λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 145495.182
   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 = 2.0676123E-010
      Vu = 1.4835100E-013
    d = 0.8*h = 160.00
    Nu = 141550.243
    Ag = 40000.00
    From (11.5.4.8), ACI 318-14: Vs = 125663.706
      Av = 157079.633

fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00

Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo
-------------------------------------------------------------

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

----------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 157.00
  d' = 43.00
  v = 0.25044275
     N = 141550.243
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.01125287
     ωwe (5.4c) = 0.03756688
        ase ((5.4d), TBDY) = 0.1377551
           bo = 140.00
           ho = 140.00
           Σbi2 = 78400.00
        psh,min = Min(psh,x , psh,y) = 0.00785398
     --------------------------------------------------------------------
        psh,x (5.4d) = 0.00785398
           Ash = Astir*ns = 78.53982
              No stirups, ns = 2.00
           bk = 200.00
     --------------------------------------------------------------------
        psh,y (5.4d) = 0.00785398
           Ash = Astir*ns = 78.53982
              No stirups, ns = 2.00
           bk = 200.00
     --------------------------------------------------------------------
           s = 100.00
        fywe = 625.00
        fce  = 18.00
     From ((5.A5), TBDY), TBDY: εcc = 0.00514929
        λc  = confinement factor = 1.31493
  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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493

ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -6.7584E+006
Shear Force, V2 = 13868.577
Shear Force, V3 = -7.3321821E-015
Axial Force, F = -141233.232
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 = 0.01047141
θu = θy + θp = 0.01047141

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00650256 ((4.29),Biskinis Phd))
My = 4.2163E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 487.32
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0533E+012
factor = 0.39615727
Ag = 40000.00
fc' = 18.00
N = 141233.232
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 = 3.2377622E-005
with fy = 500.00
d = 157.00
ξy = 0.50819221
A = 0.07462902
B = 0.05080038
with pt = 0.00785398
pc = 0.02641339
pv = 0.01280649
N = 141233.232
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9404180E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53335448

A = 0.05179231
B = 0.04180463
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00396884
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.52409919
d = 157.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
Av = 157.0796, 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 = 141233.232
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
b = 200.00
d = 157.00
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

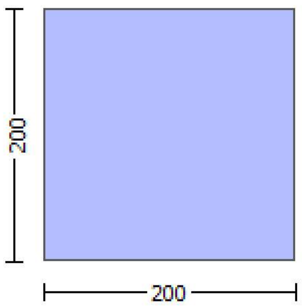
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

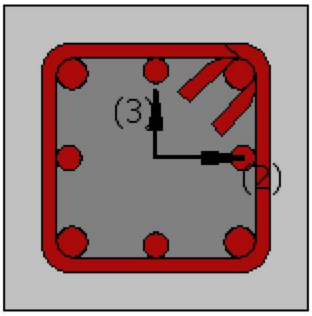
Analysis: Uniform +X

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 = -5.2364E+007
Shear Force, Va = -16198.06
EDGE -B-
Bending Moment, Mb = -7.2157E+006
Shear Force, Vb = 16198.06
BOTH EDGES
Axial Force, F = -141103.018
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 97728.154
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 97728.154
VCol = 97728.154
knl = 1.00
displacement_ductility_demand = 0.60055793

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 = 5.2364E+007
Vu = 16198.06
d = 0.8*h = 160.00
Nu = 141103.018
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 0.02591848
θy = (My*Ls/3)/EIeff = 0.04315733 ((4.29),Biskinis Phd))
My = 4.2164E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3232.754
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00
N = 141103.018
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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141103.018

b = 200.00
δ" = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965
A = 0.05180507
B = 0.04180463
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

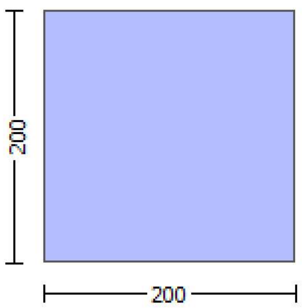
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

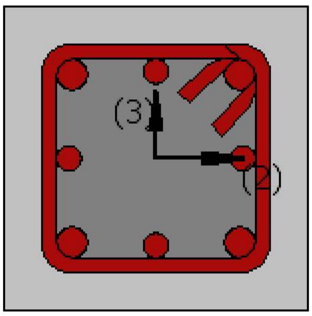
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007

----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732

```
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo
----------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
------------------------------------------------------------------------
------------------------------------------------------------------------
------------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------------

------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
------------------------------------------------------------------------
with full section properties:
   b = 200.00
   d = 157.00
   d' = 43.00
   v = 0.25044275
      N = 141550.243
   fc = 18.00
   εco (5A.5, TBDY) = 0.002
   Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
      The Shear_factor is considered equal to 1 (pure moment strength)
      From (5.4b), TBDY: εcu = 0.01125287
      ωwe (5.4c) = 0.03756688
         ase ((5.4d), TBDY) = 0.1377551
            bo = 140.00
            ho = 140.00
            Σbi2 = 78400.00
         psh,min = Min(psh,x , psh,y) = 0.00785398
      ----------------------------------------------------------------
         psh,x (5.4d) = 0.00785398
            Ash = Astir*ns = 78.53982
               No stirups, ns = 2.00
            bk = 200.00
      ----------------------------------------------------------------
         psh,y (5.4d) = 0.00785398
            Ash = Astir*ns = 78.53982
               No stirups, ns = 2.00
            bk = 200.00
      ----------------------------------------------------------------
            s = 100.00
         fywe = 625.00
         fce  = 18.00
      From ((5.A5), TBDY), TBDY: εcc = 0.00514929
         λc  = confinement factor = 1.31493
   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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007

----

with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398

----

psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853

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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.0676123E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
  b = 200.00
  d = 157.00
  d' = 43.00
  v = 0.25044275
    N = 141550.243
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: εcu = 0.01125287
    ωwe (5.4c) = 0.03756688
      ase ((5.4d), TBDY) = 0.1377551
        bo = 140.00
        ho = 140.00
        Σbi2 = 78400.00
      psh,min = Min(psh,x , psh,y) = 0.00785398
    ----
      psh,x (5.4d) = 0.00785398
        Ash = Astir*ns = 78.53982
          No stirups, ns = 2.00
        bk = 200.00
    ----
      psh,y (5.4d) = 0.00785398
        Ash = Astir*ns = 78.53982
          No stirups, ns = 2.00
        bk = 200.00
    ----
        s = 100.00
      fywe = 625.00
      fce = 18.00
    From ((5.A5), TBDY), TBDY: εcc = 0.00514929
      λc = confinement factor = 1.31493
  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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
  b = 200.00
  d = 157.00
  d' = 43.00
  v = 0.25044275
    N = 141550.243
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: εcu = 0.01125287
    ωwe (5.4c) = 0.03756688
      ase ((5.4d), TBDY) = 0.1377551
        bo = 140.00
        ho = 140.00
        Σbi2 = 78400.00
      psh,min = Min(psh,x , psh,y) = 0.00785398
    ----
      psh,x (5.4d) = 0.00785398
        Ash = Astir*ns = 78.53982
          No stirups, ns = 2.00

bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00

d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00

d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005

Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -6.5010663E-009
Shear Force, V2 = -16198.06
Shear Force, V3 = 4.0619080E-012
Axial Force, F = -141103.018
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 0.05585561
θu = θy + θp = 0.05585561

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.02002503 ((4.29),Biskinis Phd))
My = 4.2164E+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 = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00
N = 141103.018
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 = 3.2375479E-005
 with fy = 500.00
      d = 157.00
      ξy = 0.50815966
      A = 0.07462073
      B = 0.05079209
       with pt = 0.00785398
            pc = 0.02641339
            pv = 0.01280649
            N = 141103.018
            b = 200.00
            δ'' = 0.27388535
Φy_comp = 1.9406539E-005
 with fc = 18.00
      Ec = 19940.411
      ξy = 0.53328965
      A = 0.05180507
      B = 0.04180463
       with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

 - Calculation of θp -

From table 10-8: θp = 0.03583058
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VCol0E = 0.42448768
   d = 157.00
   s = 150.00
   ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
   Av = 157.0796, 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 = 141103.018
     Ag = 40000.00
     f'cE = 18.00
     fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
   b = 200.00
   d = 157.00
     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

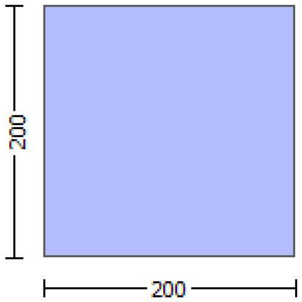
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

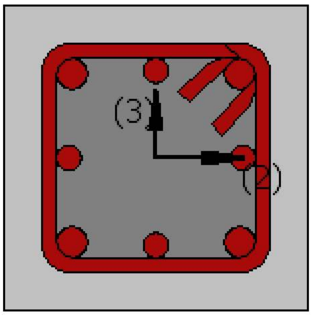
Analysis: Uniform +X

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 = -6.5010663E-009
Shear Force, Va = 4.0619080E-012
EDGE -B-
Bending Moment, Mb = -4.9035068E-009
Shear Force, Vb = -4.0619080E-012
BOTH EDGES
Axial Force, F = -141103.018
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 121817.397
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 121817.397
VCol = 121817.397
knl = 1.00
displacement_ductility_demand = 2.2204460E-016

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 = 6.5010663E-009
Vu = 4.0619080E-012
d = 0.8*h = 160.00
Nu = 141103.018
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.8368310E-018
θy = (My*Ls/3)/Eleff = 0.02002503 ((4.29),Biskinis Phd))
My = 4.2164E+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 = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00

N = 141103.018
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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141103.018
b = 200.00
δ" = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965
A = 0.05180507
B = 0.04180463
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

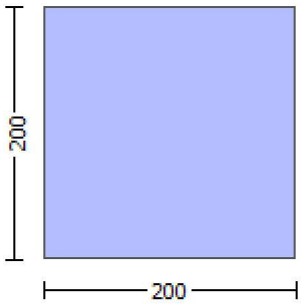
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

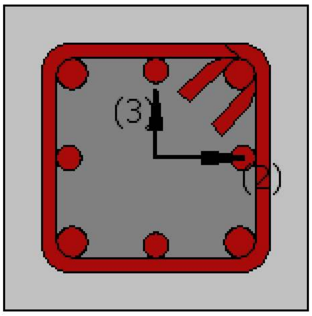
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871

εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00

v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.0676123E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00

psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied

--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -5.2364E+007
Shear Force, V2 = -16198.06
Shear Force, V3 = 4.0619080E-012
Axial Force, F = -141103.018
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1231.504
-Compression: Aslc = 829.3805
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 = 0.07898791
θu = θy + θp = 0.07898791

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.04315733 ((4.29),Biskinis Phd))
My = 4.2164E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3232.754
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00
N = 141103.018
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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.00785398
pc = 0.02641339
pv = 0.01280649
N = 141103.018
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965
A = 0.05180507
B = 0.04180463
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03583058
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VColOE = 0.52409919
d = 157.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
Av = 157.0796, 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 = 141103.018
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
b = 200.00
d = 157.00
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

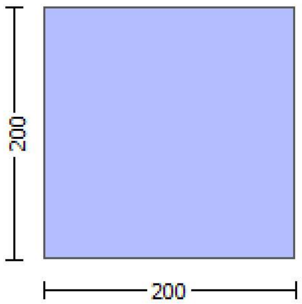
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

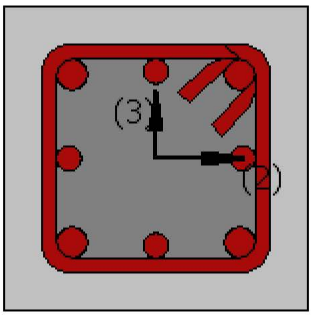
Analysis: Uniform +X

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 = -5.2364E+007
Shear Force, Va = -16198.06
EDGE -B-
Bending Moment, Mb = -7.2157E+006
Shear Force, Vb = 16198.06
BOTH EDGES
Axial Force, F = -141103.018
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 = 108247.949
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 108247.949
VCol = 108247.949
knl = 1.00
displacement_ductility_demand = 1.25184

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 = 2.78416
Mu = 7.2157E+006
Vu = 16198.06
d = 0.8*h = 160.00
Nu = 141103.018
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633

fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 0.00744463
θy = (My*Ls/3)/EIeff = 0.00594697 ((4.29),Biskinis Phd))
My = 4.2164E+007
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 445.465
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00
N = 141103.018
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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141103.018
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965
A = 0.05180507
B = 0.04180463
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

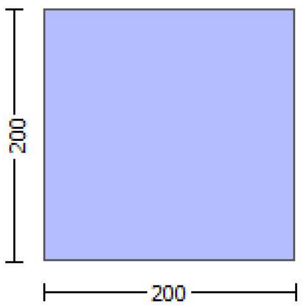
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

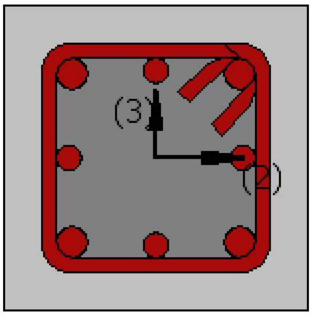
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00

fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00

d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007

----

with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398

----

psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929

λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 145495.182
   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 = 2.0676123E-010
      Vu = 1.4835100E-013
    d = 0.8*h = 160.00
    Nu = 141550.243
    Ag = 40000.00
    From (11.5.4.8), ACI 318-14: Vs = 125663.706
      Av = 157079.633

fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00

Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982

No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493

ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -4.9035068E-009
Shear Force, V2 = 16198.06
Shear Force, V3 = -4.0619080E-012
Axial Force, F = -141103.018
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 = 0.05585561
θu = θy + θp = 0.05585561

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.02002503 ((4.29),Biskinis Phd))
My = 4.2164E+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 = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00
N = 141103.018
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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.00785398
pc = 0.02641339
pv = 0.01280649
N = 141103.018
b = 200.00
δ'' = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965

A = 0.05180507
B = 0.04180463
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03583058
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.42448768
d = 157.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
Av = 157.0796, 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 = 141103.018
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
b = 200.00
d = 157.00
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

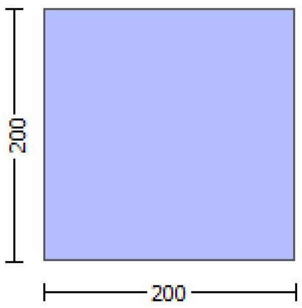
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

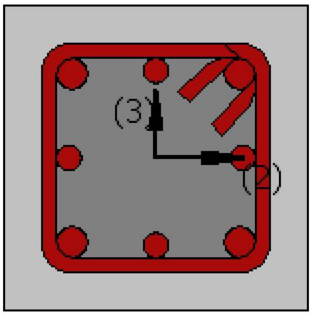
Analysis: Uniform +X

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 = -6.5010663E-009
Shear Force, Va = 4.0619080E-012
EDGE -B-
Bending Moment, Mb = -4.9035068E-009
Shear Force, Vb = -4.0619080E-012
BOTH EDGES
Axial Force, F = -141103.018
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 = 121817.397
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 121817.397
VCol = 121817.397
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 = 4.9035068E-009
Vu = 4.0619080E-012
d = 0.8*h = 160.00
Nu = 141103.018
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 100530.965
Av = 157079.633
fy = 400.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 2.9003336E-019
θy = (My*Ls/3)/EIeff = 0.02002503 ((4.29),Biskinis Phd))
My = 4.2164E+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 = 1.0528E+012
factor = 0.39597641
Ag = 40000.00
fc' = 18.00
N = 141103.018
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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.02641339
pc = 0.02641339
pv = 0.01280649
N = 141103.018

b = 200.00
δ" = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965
A = 0.05180507
B = 0.04180463
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

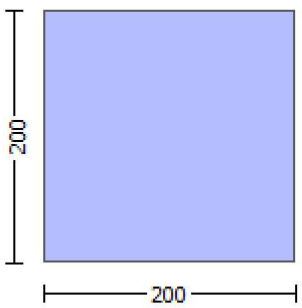
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

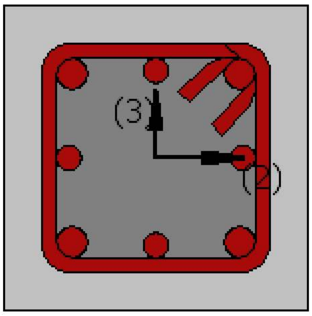
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column 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 = 1.31493
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 1.4835100E-013
EDGE -B-
Shear Force, Vb = -1.4835100E-013
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.42448768
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007

----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732

MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007

----

with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398

----

psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00

----

s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853

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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 145495.182

Calculation of Shear Strength at edge 1, Vr1 = 145495.182
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.0676123E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 145495.182
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 145495.182
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 = 2.4718313E-010
Vu = 1.4835100E-013
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 1.31493
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 = -0.00116078
EDGE -B-
Shear Force, Vb = 0.00116078
BOTH EDGES
Axial Force, F = -141550.243
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

Calculation of Shear Capacity ratio , Ve/Vr = 0.52409919
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 61760.913
with
Mpr1 = Max(Mu1+ , Mu1-) = 9.2641E+007
Mu1+ = 9.2641E+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- = 9.2641E+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-) = 9.2641E+007
Mu2+ = 9.2641E+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- = 9.2641E+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 = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Adequate Lap Length: lb/ld >= 1
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
---------------------------------------------------------------------------
with full section properties:
  b = 200.00
  d = 157.00
  d' = 43.00
  v = 0.25044275
     N = 141550.243
  fc = 18.00
  εco (5A.5, TBDY) = 0.002
  Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
     The Shear_factor is considered equal to 1 (pure moment strength)
     From (5.4b), TBDY: εcu = 0.01125287
     ωwe (5.4c) = 0.03756688
        ase ((5.4d), TBDY) = 0.1377551
           bo = 140.00
           ho = 140.00
           Σbi2 = 78400.00
        psh,min = Min(psh,x , psh,y) = 0.00785398
     ---------------------------------------------------------------------
        psh,x (5.4d) = 0.00785398
           Ash = Astir*ns = 78.53982
              No stirups, ns = 2.00
           bk = 200.00
     ---------------------------------------------------------------------
        psh,y (5.4d) = 0.00785398
           Ash = Astir*ns = 78.53982
              No stirups, ns = 2.00
           bk = 200.00
     ---------------------------------------------------------------------
           s = 100.00
        fywe = 625.00
        fce  = 18.00
     From ((5.A5), TBDY), TBDY: εcc = 0.00514929
        λc  = confinement factor = 1.31493
  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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00
d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00

bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00

d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5523896E-005
Mu = 9.2641E+007
----
with full section properties:
b = 200.00

d = 157.00
d' = 43.00
v = 0.25044275
N = 141550.243
fc = 18.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.01125287
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.01125287
ωwe (5.4c) = 0.03756688
ase ((5.4d), TBDY) = 0.1377551
bo = 140.00
ho = 140.00
Σbi2 = 78400.00
psh,min = Min(psh,x , psh,y) = 0.00785398
----
psh,x (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
psh,y (5.4d) = 0.00785398
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 200.00
----
s = 100.00
fywe = 625.00
fce = 18.00
From ((5.A5), TBDY), TBDY: εcc = 0.00514929
λc = confinement factor = 1.31493
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) = 0.91713161
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.91713161
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.44466987
and confined core properties:
b = 140.00
d = 127.00
d' = 13.00
fcc (5A.2, TBDY) = 23.66871
εcc (5A.5, TBDY) = 0.00514929
λc = confinement factor = 1.31493
ω1 = Asl,ten/(b*d)*(fs1/fc) = 1.61968
ω2 = Asl,com/(b*d)*(fs2/fc) = 1.61968
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.7853
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) = 0.47589118
MRc (4.17) = 7.5597E+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 satisfied
--->
ξ*cu (4.10) = 0.53685732
MRo (4.17) = 9.2641E+007
--->
φu = φcu (4.2) = 7.5523896E-005

Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 117842.03

Calculation of Shear Strength at edge 1, Vr1 = 117842.03
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 5.0502E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = 117842.03
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 117842.03
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 = 4.0168E+006
Vu = 0.00116078
d = 0.8*h = 160.00
Nu = 141550.243
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = 125663.706
Av = 157079.633
fy = 500.00
s = 100.00
Vs is multiplied by αCol = 1.00
s/d = 0.625
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 = -7.2157E+006
Shear Force, V2 = 16198.06
Shear Force, V3 = -4.0619080E-012
Axial Force, F = -141103.018
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 = 0.04177754
θu = θy + θp = 0.04177754

 - Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00594697 ((4.29),Biskinis Phd))
 My = 4.2164E+007
 Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 445.465
 From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 1.0528E+012
 factor = 0.39597641
 Ag = 40000.00
 fc' = 18.00
 N = 141103.018
 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 = 3.2375479E-005
with fy = 500.00
d = 157.00
ξy = 0.50815966
A = 0.07462073
B = 0.05079209
with pt = 0.00785398
pc = 0.02641339
pv = 0.01280649
N = 141103.018
b = 200.00
δ" = 0.27388535
Φy_comp = 1.9406539E-005
with fc = 18.00
Ec = 19940.411
ξy = 0.53328965
A = 0.05180507
B = 0.04180463
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.03583058
with:
- Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
shear control ratio VyE/VCol0E = 0.52409919
d = 157.00
s = 150.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00785398
Av = 157.0796, 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 = 141103.018
Ag = 40000.00
f'cE = 18.00
fytE = fylE = 500.00
pl = Area_Tot_Long_Rein/(b*d) = 0.06563327
b = 200.00
d = 157.00
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)
