Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

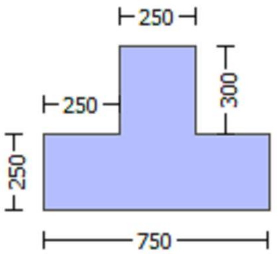
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

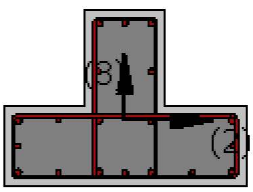
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -9.3835E+006
Shear Force, Va = -3098.679
EDGE -B-
Bending Moment, Mb = 84999.85
Shear Force, Vb = 3098.679
BOTH EDGES
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 216974.614
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 255264.252
VCol = 255264.252
knl = 1.00
displacement_ductility_demand = 0.00708481

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 9.3835E+006
Vu = 3098.679
d = 0.8*h = 600.00
Nu = 10173.224
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 179519.58
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00

Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 179519.58 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 398582.298
bw = 250.00

----
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 = 6.8307167E-005
θy = (My*Ls/3)/EIeff = 0.00964136 ((4.29),Biskinis Phd))
My = 5.5288E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.217
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7138797E-006
with fy = 444.44
d = 707.00
ξy = 0.3332159
A = 0.02927922
B = 0.01559081
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.224
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2805386E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.33274131
A = 0.02898169
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1

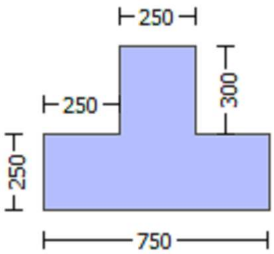
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

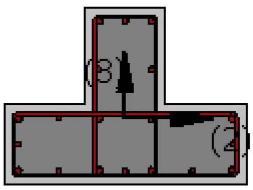
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55

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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008

MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55

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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008

φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->

v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:

d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----

with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00

d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335

fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.

with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243

The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
$\varepsilon y1$ = 0.00231479
$\varepsilon sh1$ = 0.008
ft1 = 666.66
fy1 = 555.55
$\varepsilon su1$ = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
$\varepsilon su1$ = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and $\varepsilon y1$,$\varepsilon sh1$,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
$\varepsilon y1$,$\varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
$\varepsilon y2$ = 0.00231479
$\varepsilon sh2$ = 0.008
ft2 = 666.66
fy2 = 555.55
$\varepsilon su2$ = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and $\varepsilon y2$,$\varepsilon sh2$,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
$\varepsilon y1$,$\varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479

$\varepsilon shv = 0.008$
ftv = 666.66
fyv = 555.55
$\varepsilon suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and $\varepsilon yv, \varepsilon shv$,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
$\varphi u = \varphi su$ (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206

where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -136150.98
Shear Force, V2 = -3098.679
Shear Force, V3 = 69.84092
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00843421
θu = θy + θp = 0.0099226

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.0099226 ((4.29),Biskinis Phd))
My = 5.3829E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1949.444
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

$\Phi y = Min(\Phi y\_ten,\Phi y\_com)$
$\Phi y\_ten = 7.7096332E-006$
with fy = 444.44
d = 507.00
$\xi y = 0.4314856$
A = 0.04082921
B = 0.02740052
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.224
b = 250.00
δ" = 0.08481262
$\Phi y\_comp = 7.8294955E-006$
with fc = 20.00
Ec = 21019.039
$\xi y = 0.43146732$
A = 0.0404143
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.75287
d = 507.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1360.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10173.224
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
b = 250.00
d = 507.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

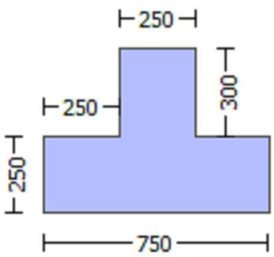
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

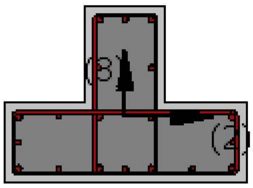
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not 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 = -136150.98
Shear Force, Va = 69.84092
EDGE -B-
Bending Moment, Mb = -72899.216
Shear Force, Vb = -69.84092
BOTH EDGES
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 159341.688
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 187460.81
VCol = 187460.81
knl = 1.00
displacement_ductility_demand = 0.00136404

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 136150.98
Vu = 69.84092
d = 0.8*h = 440.00
Nu = 10173.224
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 131647.692
where:
Vs1 = 131647.692 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 292293.685
bw = 250.00

----

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 = 1.3534816E-005
θy = (My*Ls/3)/EIeff = 0.0099226 ((4.29),Biskinis Phd))
My = 5.3829E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1949.444
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7096332E-006
with fy = 444.44
d = 507.00
ξy = 0.4314856
A = 0.04082921
B = 0.02740052
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.224
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8294955E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43146732
A = 0.0404143
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

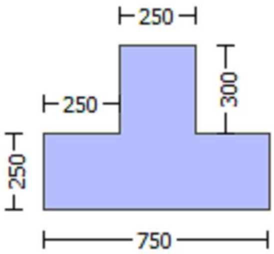
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

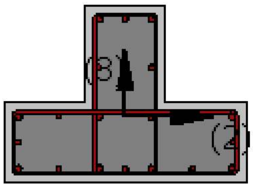
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008

ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel

--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00

fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00

Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.

with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00

s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00

Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -9.3835E+006
Shear Force, V2 = -3098.679
Shear Force, V3 = 69.84092
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00819516
θu = θy + θp = 0.00964136

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00964136 ((4.29),Biskinis Phd))
My = 5.5288E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.217
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7138797E-006
with fy = 444.44
d = 707.00
ξy = 0.3332159
A = 0.02927922
B = 0.01559081
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.224
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2805386E-006

with fc = 20.00
Ec = 21019.039
ξy = 0.33274131
A = 0.02898169
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.87963
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10173.224
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1

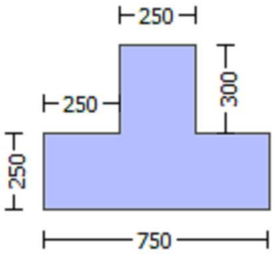
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

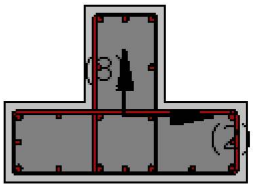
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -9.3835E+006
Shear Force, Va = -3098.679
EDGE -B-
Bending Moment, Mb = 84999.85
Shear Force, Vb = 3098.679
BOTH EDGES
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 281357.585
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 331008.924
VCol = 331008.924
knl = 1.00
displacement_ductility_demand = 0.02587648

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 84999.85
Vu = 3098.679
d = 0.8*h = 600.00
Nu = 10173.224
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 179519.58
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 179519.58 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 398582.298
bw = 250.00

----
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 = 2.4715982E-005
θy = (My*Ls/3)/Eleff = 0.00095515 ((4.29),Biskinis Phd))
My = 5.5288E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7138797E-006
with fy = 444.44
d = 707.00
ξy = 0.3332159
A = 0.02927922
B = 0.01559081
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.224
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2805386E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.33274131
A = 0.02898169
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

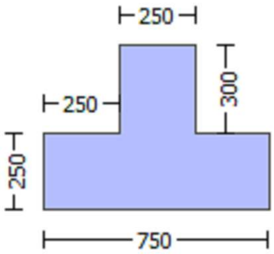
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

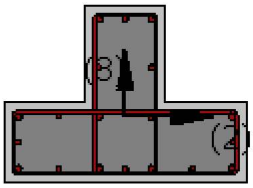
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00

fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
   b = 750.00
   d = 507.00
   d' = 43.00
   v = 0.00129748
      N = 9867.335
   fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55

with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008

ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->

ξ^*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
$\varphi u = \varphi cu$ (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu^* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to $\Sigma bi2/6$ as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
$\varepsilon y1$ = 0.00231479
$\varepsilon sh1$ = 0.008

ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->

ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00

d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00

εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -72899.216
Shear Force, V2 = 3098.679
Shear Force, V3 = -69.84092
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00451592
θu = θy + θp = 0.00531285

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00531285 ((4.29),Biskinis Phd))
My = 5.3829E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1043.789
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7096332E-006
with fy = 444.44
d = 507.00
ξy = 0.4314856
A = 0.04082921
B = 0.02740052
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.224
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8294955E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43146732
A = 0.0404143
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.75287
d = 507.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1360.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10173.224
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
b = 250.00
d = 507.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

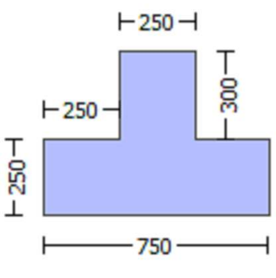
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

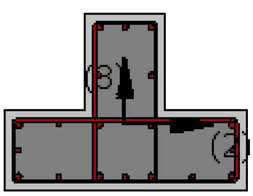
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -136150.98
Shear Force, Va = 69.84092
EDGE -B-
Bending Moment, Mb = -72899.216
Shear Force, Vb = -69.84092
BOTH EDGES
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 191894.088
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 225757.751
VCol = 225757.751
knl = 1.00
displacement_ductility_demand = 8.1623688E-007

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.37225
Mu = 72899.216
Vu = 69.84092
d = 0.8*h = 440.00
Nu = 10173.224
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 131647.692
where:
Vs1 = 131647.692 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 292293.685
bw = 250.00

----
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 = 4.3365448E-009
θy = (My*Ls/3)/EIeff = 0.00531285 ((4.29),Biskinis Phd))
My = 5.3829E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1043.789
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7096332E-006
with fy = 444.44
d = 507.00
ξy = 0.4314856
A = 0.04082921
B = 0.02740052
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10173.224

b = 250.00
δ" = 0.08481262
Φy_comp = 7.8294955E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43146732
A = 0.0404143
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

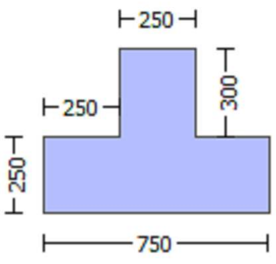
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

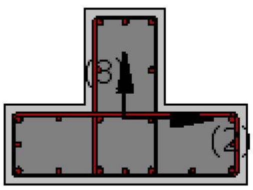
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55

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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->

Subcase: Rupture of tension steel
--->
$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
--->
$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is not satisfied
--->
$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied
--->
ξ^*_{cu} (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
$\varphi_u = \varphi_{cu}$ (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00

d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758

Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002

λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00

d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment

direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.

with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479

εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00

s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 84999.85
Shear Force, V2 = 3098.679
Shear Force, V3 = -69.84092
Axial Force, F = -10173.224
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.00081188
θu = θy + θp = 0.00095515

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00095515 ((4.29),Biskinis Phd))
My = 5.5288E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10173.224
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7138797E-006
with fy = 444.44
d = 707.00
ξy = 0.3332159
A = 0.02927922
B = 0.01559081
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10173.224
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2805386E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.33274131
A = 0.02898169
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.00
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.87963
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10173.224
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 3
Integration Section: (b)

Calculation No. 9

column C1, Floor 1

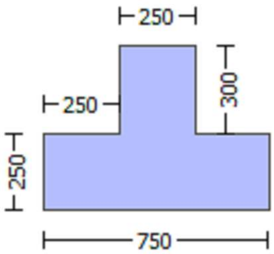
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

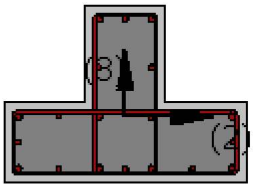
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 550.00

Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4243E+007
Shear Force, Va = -4703.287
EDGE -B-
Bending Moment, Mb = 129016.178
Shear Force, Vb = 4703.287
BOTH EDGES
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 216987.897
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 255279.879
VCol = 255279.879
knl = 1.00
displacement_ductility_demand = 0.01075281

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1.4243E+007
Vu = 4703.287
d = 0.8*h = 600.00
Nu = 10331.624
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 179519.58
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 179519.58 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00

s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 398582.298
bw = 250.00

----
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 = 0.00010368
θy = (My*Ls/3)/Eleff = 0.00964205 ((4.29),Biskinis Phd))
My = 5.5292E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.217
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7140275E-006
with fy = 444.44
d = 707.00
ξy = 0.33323681
A = 0.02928124
B = 0.01559283
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10331.624
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2802408E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.33275492
A = 0.02897907
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

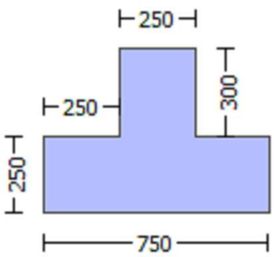
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

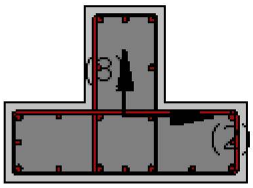
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.

with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767

Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00

ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00

Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55

with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008

ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00

s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:

Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -206082.005
Shear Force, V2 = -4703.287
Shear Force, V3 = 106.0071
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.03104978
θu = θy + θp = 0.03652915

- Calculation of θy -

θy = (My*Ls/3)/Eleff = 0.00989558 ((4.29),Biskinis Phd))
My = 5.3831E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1944.04
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7098847E-006
with fy = 444.44
d = 507.00
ξy = 0.43150415
A = 0.04083202
B = 0.02740333

with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10331.624
b = 250.00
δ" = 0.08481262
Φy_comp = 7.8291624E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43148568
A = 0.04041066
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.02663357
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.75287
d = 507.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1360.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10331.624
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
b = 250.00
d = 507.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

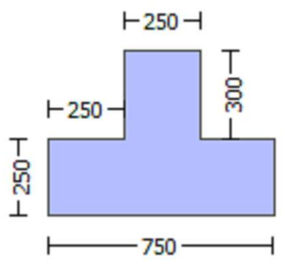
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

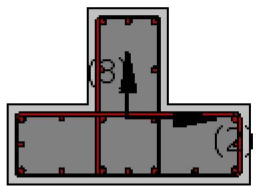
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -206082.005
Shear Force, Va = 106.0071
EDGE -B-
Bending Moment, Mb = -111221.978
Shear Force, Vb = -106.0071
BOTH EDGES
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 159354.907
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 187476.361
VCol = 187476.361
knl = 1.00
displacement_ductility_demand = 0.00207604

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 206082.005
Vu = 106.0071
d = 0.8*h = 440.00
Nu = 10331.624
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 131647.692
where:
Vs1 = 131647.692 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 292293.685
bw = 250.00

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 2.0543636E-005
θy = (My*Ls/3)/Eleff = 0.00989558 ((4.29),Biskinis Phd))

My = 5.3831E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1944.04
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7098847E-006
with fy = 444.44
d = 507.00
ξy = 0.43150415
A = 0.04083202
B = 0.02740333
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10331.624
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8291624E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43148568
A = 0.04041066
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

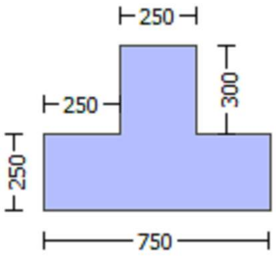
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

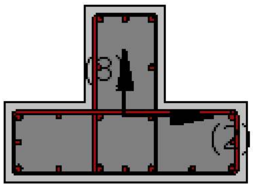
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: Start

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

----

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----

s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008

ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel

--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00

fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431

knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00

Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
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J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
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Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.

with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00

s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00

Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lb/ld>=1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -1.4243E+007
Shear Force, V2 = -4703.287
Shear Force, V3 = 106.0071
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0332835
θu = θy + θp = 0.03915706

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00964205 ((4.29),Biskinis Phd))
My = 5.5292E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3028.217
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7140275E-006
with fy = 444.44
d = 707.00
ξy = 0.33323681
A = 0.02928124
B = 0.01559283
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10331.624
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2802408E-006

with fc = 20.00
Ec = 21019.039
ξy = 0.33275492
A = 0.02897907
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.02951501
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VCol0E = 1.87963
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10331.624
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

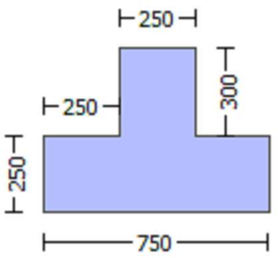
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

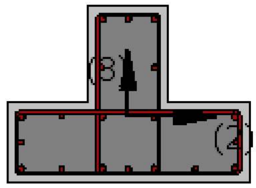
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min = lb/ld >=1)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4243E+007
Shear Force, Va = -4703.287
EDGE -B-
Bending Moment, Mb = 129016.178
Shear Force, Vb = 4703.287
BOTH EDGES
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 281384.151
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 331040.178
VCol = 331040.178
knl = 1.00
displacement_ductility_demand = 0.03927346

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 129016.178
Vu = 4703.287
d = 0.8*h = 600.00
Nu = 10331.624
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 179519.58
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 179519.58 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 398582.298
bw = 250.00

----
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 = 3.7514816E-005
θy = (My*Ls/3)/Eleff = 0.00095522 ((4.29),Biskinis Phd))
My = 5.5292E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7140275E-006
with fy = 444.44
d = 707.00
ξy = 0.33323681
A = 0.02928124
B = 0.01559283
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10331.624
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2802408E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.33275492
A = 0.02897907
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

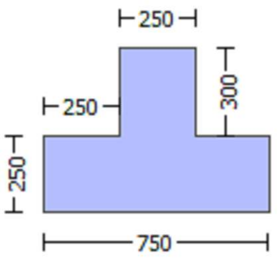
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

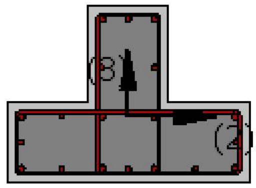
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (2)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00

fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture

δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
   - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
   - N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
   - σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
   b = 750.00
   d = 507.00
   d' = 43.00
   v = 0.00129748
       N = 9867.335
   fc = 20.00

εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55

with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008

ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->

ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008

ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->

ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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, V_a = -7.6387182E-037
EDGE -B-
Shear Force, V_b = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete." J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953

ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00

d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00

εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194

ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -111221.978
Shear Force, V2 = 4703.287
Shear Force, V3 = -106.0071
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.02717806
θu = θy + θp = 0.03197419

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00534062 ((4.29),Biskinis Phd))
My = 5.3831E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1049.194
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7098847E-006
with fy = 444.44
d = 507.00
ξy = 0.43150415
A = 0.04083202
B = 0.02740333
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10331.624
b = 250.00
δ'' = 0.08481262
Φy_comp = 7.8291624E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43148568
A = 0.04041066
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.02663357
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VCol0E = 1.75287
  d = 507.00
  s = 0.00
  ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
  Av = 78.53982, is the area of every stirrup
  Lstir = 1360.00, is the total Length of all stirrups parallel to loading (shear) direction
  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 = 10331.624
    Ag = 262500.00
    f'cE = 20.00
    fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.04064862
  b = 250.00
  d = 507.00
    f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

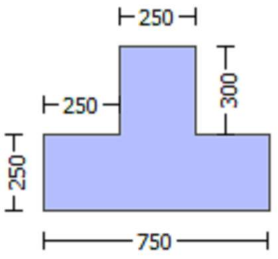
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

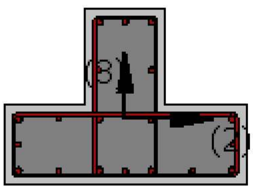
Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of θy for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -206082.005
Shear Force, Va = 106.0071
EDGE -B-
Bending Moment, Mb = -111221.978
Shear Force, Vb = -106.0071
BOTH EDGES
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = κ*Vn = 191504.22
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 225299.082
VCol = 225299.082
knl = 1.00
displacement_ductility_demand = 1.2324716E-006

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

λ = 1 (normal-weight concrete)
fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.38453
Mu = 111221.978
Vu = 106.0071
d = 0.8*h = 440.00
Nu = 10331.624
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 131647.692
where:
Vs1 = 131647.692 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 400.00
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 292293.685
bw = 250.00

----
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 = 6.5821653E-009
θy = (My*Ls/3)/EIeff = 0.00534062 ((4.29),Biskinis Phd))
My = 5.3831E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1049.194
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 3.5251E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.1750E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 7.7098847E-006
with fy = 444.44
d = 507.00
ξy = 0.43150415
A = 0.04083202
B = 0.02740333
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10331.624

b = 250.00
δ" = 0.08481262
Φy_comp = 7.8291624E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.43148568
A = 0.04041066
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

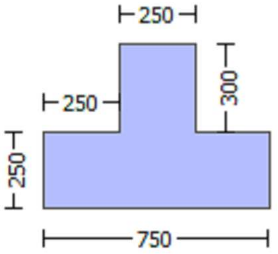
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

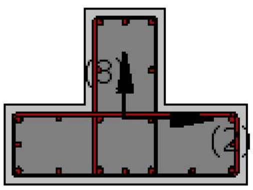
Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)





Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 1.2475386E-020
EDGE -B-
Shear Force, Vb = -1.2475386E-020
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885

Calculation of Shear Capacity ratio , Ve/Vr = 1.75287
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 474640.944
with
Mpr1 = Max(Mu1+ , Mu1-) = 7.1196E+008
Mu1+ = 6.7333E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 7.1196E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 7.1196E+008
Mu2+ = 6.7333E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 7.1196E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55

$\varepsilon su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
$\varepsilon su2$ = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and $\varepsilon y2, \varepsilon sh2$,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
$\varepsilon yv = 0.00231479$
$\varepsilon shv = 0.008$
ftv = 666.66
fyv = 555.55
$\varepsilon suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
εsuv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and $\varepsilon yv, \varepsilon shv$,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
$\varepsilon y1, \varepsilon sh1$,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < $\tilde{v}$s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, $\rho 1$, $\rho 2$, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->

Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00

d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

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 = 2.5212549E-005
Mu = 6.7333E+008
----
with full section properties:
b = 250.00
d = 507.00
d' = 43.00
v = 0.00389244
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758

Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.49570986
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.18176028
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.45164676
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002

λc = confinement factor = 1.00
$\omega 1$ = Asl,ten/(b*d)*(fs1/fc) = 0.69327182
$\omega 2$ = Asl,com/(b*d)*(fs2/fc) = 0.25419967
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.63164766
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfinesd full section - Spalling of concrete cover
δ' satisfies Eq. (4.4)
--->
v < ṽs,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
ξcu (4.10) = 0.45563712
MRc (4.17) = 6.7333E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, ρ1, ρ2, ρv normalised to bo*do, instead of b*d
- σ-ε parameters of confined concrete, fcc, εcc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
ξ*cu (4.11) = 0.50925545
MRo (4.18) = 5.1054E+008
MRo < 0.8*MRc
--->
φu = φcu (unconfined full section) = 2.5212549E-005
Mu = MRc

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5506193E-005
Mu = 7.1196E+008
----
with full section properties:
b = 750.00

d = 507.00
d' = 43.00
v = 0.00129748
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06058676
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.16523662
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.15054892
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.06999701
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19090094
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.17393196
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.16409014
Mu = MRc (4.15) = 7.1196E+008
φu = φsu (4.1) = 7.5506193E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 270779.431

Calculation of Shear Strength at edge 1, Vr1 = 270779.431
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 270779.431
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 270779.431
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1106.333
Vu = 1.2475386E-020
d = 0.8*h = 440.00
Nu = 9867.335
Ag = 137500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 146273.751
where:
Vs1 = 146273.751 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 1.00
s/d = 0.47727273
Vs2 = 0.00 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 326794.274
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = -7.6387182E-037
EDGE -B-
Shear Force, Vb = 7.6387182E-037
BOTH EDGES
Axial Force, F = -9867.335
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203

Calculation of Shear Capacity ratio , Ve/Vr = 1.87963
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 692714.257
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.0391E+009
Mu1+ = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
Mu1- = 1.0391E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment

direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.0391E+009
Mu2+ = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
Mu2- = 1.0391E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate curvature φu according to 4.1, Biskinis/Fardis 2013:
φu = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.

with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479
εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

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 = 7.5114704E-005
Mu = 1.0391E+009
----
with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00279133
N = 9867.335
fc = 20.00
εco (5A.5, TBDY) = 0.002
Final value of εcu: εcu* = shear_factor * Max(εcu,εcc) = 0.0058243
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: εcu = 0.0058243
ωwe (5.4c) = 0.00337648
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.20910778
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 80100.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to Σbi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00193767
Expression ((5.4d), TBDY) for psh,min has been miltiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)
----
psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00193767
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00250758
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00
----
s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: εcc = 0.002
λc = confinement factor = 1.00
εy1 = 0.00231479
εsh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
εy2 = 0.00231479

εsh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
εyv = 0.00231479
εshv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.19353953
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.19353953
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.42262713
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
εcc (5A.5, TBDY) = 0.002
λc = confinement factor = 1.00
ω1 = Asl,ten/(b*d)*(fs1/fc) = 0.26594194
ω2 = Asl,com/(b*d)*(fs2/fc) = 0.26594194
ωv = Asl,mid/(b*d)*(fsv/fc) = 0.58073035
Case/Assumption: Unconfinesd full section - Steel rupture
δ' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
ξsu (4.8) = 0.39743263
Mu = MRc (4.15) = 1.0391E+009
φu = φsu (4.1) = 7.5114704E-005

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 368536.864

Calculation of Shear Strength at edge 1, Vr1 = 368536.864

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00
s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 368536.864
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 368536.864
knl = 1 (zero step-static loading)

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

λ = 1 (normal-weight concrete)
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.61123004
Vu = 7.6387182E-037
d = 0.8*h = 600.00
Nu = 9867.335
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 199464.206
where:
Vs1 = 0.00 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs1 is multiplied by αCol1 = 0.00
s/d = 1.05
Vs2 = 199464.206 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs2 is multiplied by αCol2 = 1.00

s/d = 0.35
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 445628.556
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, κ = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not 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 = 129016.178
Shear Force, V2 = 4703.287
Shear Force, V3 = -106.0071
Axial Force, F = -10331.624
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL = 17.60

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = κ*θu = 0.0258997
θu = θy + θp = 0.03047023

- Calculation of θy -

θy = (My*Ls/3)/EIeff = 0.00095522 ((4.29),Biskinis Phd))
My = 5.5292E+008
Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 5.7884E+013
factor = 0.30
Ag = 262500.00
fc' = 20.00
N = 10331.624
Ec*Ig = 1.9295E+014

Calculation of Yielding Moment My

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

Φy = Min(Φy_ten,Φy_com)
Φy_ten = 4.7140275E-006
with fy = 444.44
d = 707.00
ξy = 0.33323681
A = 0.02928124
B = 0.01559283
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10331.624
b = 250.00
δ'' = 0.06082037
Φy_comp = 7.2802408E-006
with fc = 20.00
Ec = 21019.039
ξy = 0.33275492
A = 0.02897907
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

- Calculation of θp -

From table 10-8: θp = 0.02951501
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VColOE = 1.87963
d = 707.00
s = 0.00
ρt = Av/(bw*s) + 2*tf/bw*(ffe/fs) = Av*Lstir/(Ag*s) + 2*tf/bw*(ffe/fs) = 0.00
Av = 78.53982, is the area of every stirrup
Lstir = 1760.00, is the total Length of all stirrups parallel to loading (shear) direction
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 = 10331.624
Ag = 262500.00
f'cE = 20.00
fytE = fylE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 3
Integration Section: (b)
