

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

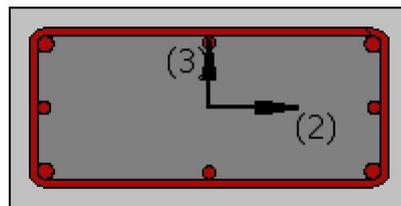
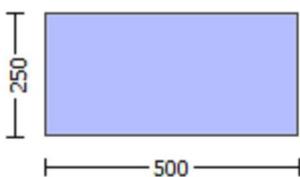
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.4198E+007$

Shear Force, $V_a = -4692.913$

EDGE -B-

Bending Moment, $M_b = 115914.626$

Shear Force, $V_b = 4692.913$

BOTH EDGES

Axial Force, $F = -4883.466$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1231.504$

-Compression: $As_c = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 829.3805$

-Compression: $As_{c,com} = 829.3805$

-Middle: $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 301636.176$

V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 301636.176$

$V_{CoI} = 301636.176$

$k_n = 1.00$

displacement_ductility_demand = 0.04064384

NOTE: In expression (10-3) ' $V_s = A_v \phi f_y d/s$ ' is replaced by ' $V_s + \phi V_f$ ' where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 1.4198E+007$

$V_u = 4692.913$

$d = 0.8 \cdot h = 400.00$

$N_u = 4883.466$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 251327.412$

$A_v = 157079.633$

$f_y = 400.00$

$s = 100.00$

V_s is multiplied by $\phi_{CoI} = 1.00$

$s/d = 0.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 250.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 0.00024437$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00601254$ ((4.29), Biskinis Phd))
 $M_y = 9.7901E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3025.481
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4883.466
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.8742278E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9644$
d = 457.00
y = 0.296918
A = 0.01821006
B = 0.01003951
with pt = 0.00725935
pc = 0.00725935
pv = 0.00351968
N = 4883.466
b = 250.00
" = 0.0940919
 $y_{comp} = 1.2695211E-005$
with fc = 20.00
Ec = 21019.039
y = 0.29521167
A = 0.0179136
B = 0.00986782
with Es = 200000.00

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

Calculation No. 2

column C1, Floor 1

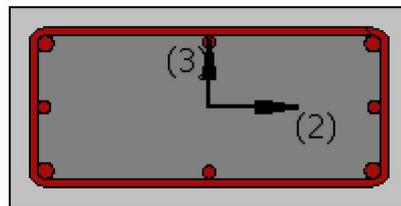
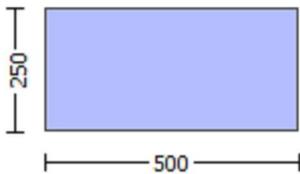
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 5.1679577E-032$

EDGE -B-

Shear Force, $V_b = -5.1679577E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 829.3805$

-Compression: $As_{c,com} = 829.3805$

-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.9340E+007$

$Mu_{1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.9340E+007$

$Mu_{2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$

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

From (5.4b), TBDY: $\phi_u = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = $Asl,ten/(b*d)*(fs1/fc)$ = 0.16570866
2 = $Asl,com/(b*d)*(fs2/fc)$ = 0.16570866
v = $Asl,mid/(b*d)*(fsv/fc)$ = 0.08034359
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.25403043
Mu = MRc (4.14) = 5.9340E+007
u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.3157250E-005
Mu = 5.9340E+007

with full section properties:

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: $cu^* = shear_factor * Max(cu, cc)$ = 0.0050171
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0050171
we (5.4c) = 0.00143849
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = $Min(psh,x, psh,y)$ = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866

2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866

v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.25403043
Mu = MRc (4.14) = 5.9340E+007
u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

Calculation of Mu₂₊

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

u = 3.3157250E-005
Mu = 5.9340E+007

with full section properties:

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.0050171
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0050171
we (5.4c) = 0.00143849
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi² = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/l_d = 0.30
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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 311.2056$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00129669$

$sh_2 = 0.0044814$

$ft_2 = 373.4467$

$fy_2 = 311.2056$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 311.2056$

with $Es_2 = Es = 200000.00$

$y_v = 0.00129669$

$sh_v = 0.0044814$

$ft_v = 373.4467$

$fy_v = 311.2056$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$su_v = 0.4 \cdot esu_{v,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{v,nominal} = 0.08$,

considering characteristic value $fsy_v = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fsy_v = fs_v/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_v = fs = 311.2056$

with $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.12468976$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.12468976$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 20.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.16570866$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.16570866$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

$su (4.9) = 0.25403043$

$Mu = MRc (4.14) = 5.9340E+007$

$u = su (4.1) = 3.3157250E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\text{psh,min} = \text{Min}(\text{psh,x}, \text{psh,y}) = 0.00314159$$

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

$$\text{psh,x (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$\text{psh,y (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal}((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $es_{u2_nominal} = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 311.2056$

with $Es_2 = Es = 200000.00$

$y_v = 0.00129669$

$sh_v = 0.0044814$

$ft_v = 373.4467$

$fy_v = 311.2056$

$s_{uv} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{u,min} = lb/d = 0.30$

$s_{uv} = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_v = fs = 311.2056$

with $Es_v = Es = 200000.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.12468976$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.12468976$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 20.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.16570866$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.16570866$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.25403043$

$M_u = MR_c (4.14) = 5.9340E+007$

$u = s_u (4.1) = 3.3157250E-005$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 251961.592$

Calculation of Shear Strength at edge 1, $V_{r1} = 251961.592$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$M_u = 3.4623283E-012$

Vu = 5.1679577E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 251961.592
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 251961.592
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 20.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.4623283E-012
Vu = 5.1679577E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

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

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

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

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, $f_s = 1.25*f_{sm} = 555.55$
#####

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -3.1643569E-048$
EDGE -B-
Shear Force, $V_b = 3.1643569E-048$
BOTH EDGES
Axial Force, $F = -4666.932$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{st,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.24493996$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.4387E+008$
 $Mu_{1+} = 1.4387E+008$, 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
 $Mu_{1-} = 1.4387E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.4387E+008$
 $Mu_{2+} = 1.4387E+008$, 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
 $Mu_{2-} = 1.4387E+008$, 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 Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.4115955E-005$
 $M_u = 1.4387E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$

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

From (5.4b), TBDY: $c_u = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$p_{sh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00129669$

$sh_1 = 0.0044814$

$ft_1 = 373.4467$

$fy_1 = 311.2056$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 311.2056$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00129669$

$sh_2 = 0.0044814$

$ft_2 = 373.4467$

$fy_2 = 311.2056$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 311.2056$

with $Es_2 = Es = 200000.00$

$y_v = 0.00129669$

$sh_v = 0.0044814$

$ft_v = 373.4467$

$fy_v = 311.2056$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1$, $sh1,ft1,fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with $fsv = fs = 311.2056$

with $Esv = Es = 200000.00$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.11295746$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.11295746$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$c =$ confinement factor = 1.00

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15907051$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15907051$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20632353$$

$$Mu = MRc (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu1$ -

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

$$u = 1.4115955E-005$$

$$Mu = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$fc = 20.00$$

$$co (5A.5, TBDY) = 0.002$$

Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$

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

From (5.4b), TBDY: $cu = 0.0050171$

$$we (5.4c) = 0.00143849$$

$$ase ((5.4d), TBDY) = 0.05494666$$

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

$$psh,min = Min(psh,x, psh,y) = 0.00314159$$

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

$$psh,x (5.4d) = 0.00314159$$

$$Ash = Astir * ns = 78.53982$$

No stirrups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = $Asl,ten/(b*d)*(fs1/fc) = 0.15907051$
2 = $Asl,com/(b*d)*(fs2/fc) = 0.15907051$
v = $Asl,mid/(b*d)*(fsv/fc) = 0.07712509$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.20632353
Mu = MRc (4.14) = 1.4387E+008
u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 1.4115955E-005
Mu = 1.4387E+008

with full section properties:

b = 250.00
d = 457.00
d' = 43.00
v = 0.00204242
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0050171
we (5.4c) = 0.00143849
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051

2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is satisfied

---->

su (4.9) = 0.20632353
Mu = MRc (4.14) = 1.4387E+008
u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

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

u = 1.4115955E-005
Mu = 1.4387E+008

with full section properties:

b = 250.00
d = 457.00
d' = 43.00
v = 0.00204242
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.0050171$
we (5.4c) = 0.00143849
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: $\phi_c = 0.002$
c = confinement factor = 1.00
y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 311.2056$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00129669$

$sh_2 = 0.0044814$

$ft_2 = 373.4467$

$fy_2 = 311.2056$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/lb_{min} = 0.30$

$su_2 = 0.4 \cdot esu_{2_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esu_{2_nominal} = 0.08$,

For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 311.2056$

with $Es_2 = Es = 200000.00$

$y_v = 0.00129669$

$sh_v = 0.0044814$

$ft_v = 373.4467$

$fy_v = 311.2056$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/ld = 0.30$

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_v = fs = 311.2056$

with $Es_v = Es = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.11295746$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.11295746$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.05476725$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

$f_{cc} (5A.2, \text{TBDY}) = 20.00$

$cc (5A.5, \text{TBDY}) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.15907051$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.15907051$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.07712509$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.20632353$

$Mu = MRc (4.14) = 1.4387E+008$

$u = su (4.1) = 1.4115955E-005$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 391586.536$

Calculation of Shear Strength at edge 1, Vr1 = 391586.536

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 391586.536

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.5320539E-012

Vu = 3.1643569E-048

d = 0.8*h = 400.00

Nu = 4666.932

Ag = 125000.00

From (11.5.4.8), ACI 318-14: Vs = 279249.888

Av = 157079.633

fy = 444.44

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.25

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 297085.704

bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 391586.536

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VColO

VColO = 391586.536

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.5320539E-012

Vu = 3.1643569E-048

d = 0.8*h = 400.00

Nu = 4666.932

Ag = 125000.00

From (11.5.4.8), ACI 318-14: Vs = 279249.888

Av = 157079.633

fy = 444.44

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.25

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 297085.704

bw = 250.00

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\phi = 1.00$
 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, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_b/l_d = 0.30$
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 9.9715419E-010$
 Shear Force, $V_2 = -4692.913$
 Shear Force, $V_3 = -3.5246242E-013$
 Axial Force, $F = -4883.466$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 1231.504$
 -Compression: $A_{sc} = 829.3805$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 829.3805$
 -Compression: $A_{st,com} = 829.3805$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $D_bL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = \phi \cdot u = 0.00531685$
 $u = y + p = 0.00531685$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00531685$ ((4.29), Biskinis Phd))
 $M_y = 4.3654E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053E+012$
 factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 8.9408280E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/l_d)^{2/3}) = 248.9644$
 $d = 207.00$
 $y = 0.32739632$

A = 0.02010145
B = 0.01221363
with pt = 0.00801334
pc = 0.00801334
pv = 0.00388525
N = 4883.466
b = 500.00
" = 0.20772947
y_comp = 2.5390422E-005
with fc = 20.00
Ec = 21019.039
y = 0.32587375
A = 0.01977419
B = 0.01202411
with Es = 200000.00

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{Col} I_{OE} = 0.15700689$

$d = 207.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$b_w = 500.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$NUD = 4883.466$

$Ag = 125000.00$

$f_{cE} = 20.00$

$f_{yE} = f_{yI} = 0.00$

$pl = \text{Area_Tot_Long_Rein} / (b * d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 20.00$

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

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

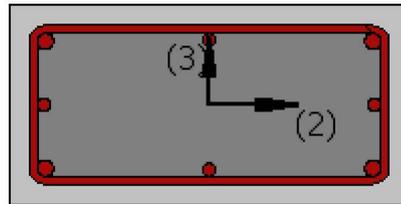
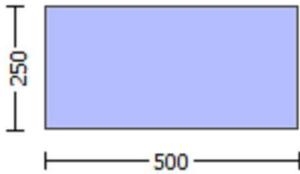
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 9.9715419E-010$

Shear Force, $V_a = -3.5246242E-013$
EDGE -B-
Bending Moment, $M_b = 6.1234342E-011$
Shear Force, $V_b = 3.5246242E-013$
BOTH EDGES
Axial Force, $F = -4883.466$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1231.504$
-Compression: $As_c = 829.3805$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 829.3805$
-Compression: $As_{,com} = 829.3805$
-Middle: $As_{,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 226281.233$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 226281.233$
 $V_{CoI} = 226281.233$
 $k_n = 1.00$
displacement_ductility_demand = 0.00

NOTE: In expression (10-3) ' $V_s = A_v \phi_f y d / s$ ' is replaced by ' $V_s + \phi V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 9.9715419E-010$
 $V_u = 3.5246242E-013$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4883.466$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 125663.706$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{CoI} = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 500.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 6.6537124E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00531685$ ((4.29), Biskinis Phd)
 $M_y = 4.3654E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 8.9408280\text{E-}006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 248.9644$
 $d = 207.00$
 $y = 0.32739632$
 $A = 0.02010145$
 $B = 0.01221363$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4883.466$
 $b = 500.00$
 $\gamma = 0.20772947$
 $y_{\text{comp}} = 2.5390422\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32587375$
 $A = 0.01977419$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

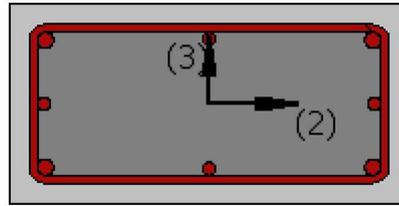
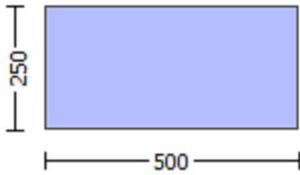
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$

 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, $f_s = 1.25 \cdot f_{sm} = 555.55$

 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 5.1679577E-032$
 EDGE -B-
 Shear Force, $V_b = -5.1679577E-032$
 BOTH EDGES
 Axial Force, $F = -4666.932$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 829.3805$
 -Compression: $A_{sl,com} = 829.3805$
 -Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 5.9340E+007$

$M_{u1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 5.9340E+007$

$M_{u2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

α (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$

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

From (5.4b), TBDY: $\phi_u = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x} , \phi_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $\phi_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

From ((5.A5), TBDY), TBDY: $\phi_c = 0.002$

c = confinement factor = 1.00

$y_1 = 0.00129669$

$sh_1 = 0.0044814$

$ft_1 = 373.4467$

$fy_1 = 311.2056$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866

2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866

v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vsy2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

Mu = MRc (4.14) = 5.9340E+007

u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_1 -

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

$$\mu = 3.3157250E-005$$

$$\mu_1 = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.12468976$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12468976$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.16570866$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.16570866$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e (5.4c) = 0.00143849$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$y_2, sh_2, f_{t2}, f_{y2}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Es = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.12468976$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.12468976$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.16570866$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.16570866$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$fc = 20.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } cu = 0.0050171$$

$$we (5.4c) = 0.00143849$$

$$ase ((5.4d), TBDY) = 0.05494666$$

$$bo = 440.00$$

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

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

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 500.00

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00129669

sh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12468976$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12468976$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 20.00$

$cc \text{ (5A.5, TBDY)} = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.16570866$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.16570866$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.25403043$

$Mu = MRc \text{ (4.14)} = 5.9340E+007$

$u = su \text{ (4.1)} = 3.3157250E-005$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 251961.592$

Calculation of Shear Strength at edge 1, $V_{r1} = 251961.592$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$Mu = 3.4623283E-012$

$Vu = 5.1679577E-032$

$d = 0.8 \cdot h = 200.00$

$Nu = 4666.932$

$Ag = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 251961.592$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 3.4623283E-012$
 $V_u = 5.1679577E-032$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 139624.944$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 100.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 500.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou, min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -3.1643569E-048$
EDGE -B-

Shear Force, $V_b = 3.1643569E-048$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 829.3805$

-Compression: $As_{c,com} = 829.3805$

-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.24493996$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.4387E+008$

$M_{u1+} = 1.4387E+008$, 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

$M_{u1-} = 1.4387E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.4387E+008$

$M_{u2+} = 1.4387E+008$, 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

$M_{u2-} = 1.4387E+008$, 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 M_{u1+}

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

$\phi_u = 1.4115955E-005$

$M_u = 1.4387E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_{cc}) = 0.0050171$

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

From (5.4b), TBDY: $\phi_c = 0.0050171$

ϕ_{we} (5.4c) = 0.00143849

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{psh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{psh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.11295746$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.11295746$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.15907051$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.15907051$

$$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s, y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.20632353$$

$$\mu_u = M_{Rc}(4.14) = 1.4387E+008$$

$$u = s_u(4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051

2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vsy2 - LHS eq.(4.5) is satisfied

su (4.9) = 0.20632353

Mu = MRc (4.14) = 1.4387E+008

u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.11295746$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.11295746$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.15907051$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.15907051$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y_2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20632353$$

$$Mu = MRc (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Mu_2 -

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

$$u = 1.4115955E-005$$

$$Mu = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$s_{u1} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$s_{u1} = 0.4 * e_{s1_nominal}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1_nominal} = 0.08,$$

For calculation of $e_{s1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{s1} = f_s = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$s_{u2} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_{u2} = 0.4 * e_{s2_nominal}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2_nominal} = 0.08,$$

For calculation of $e_{s2_nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

$y_2, sh_2, f_{t2}, f_{y2}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{s2} = f_s = 311.2056$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Es = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.11295746$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.11295746$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.15907051$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.15907051$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

$$su (4.9) = 0.20632353$$

$$Mu = MRc (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 391586.536$

Calculation of Shear Strength at edge 1, Vr1 = 391586.536

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VCol0$$

$$VCol0 = 391586.536$$

$$knl = 1 \text{ (zero step-static loading)}$$

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

= 1 (normal-weight concrete)

$$fc' = 20.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 2.5320539E-012$$

$$Vu = 3.1643569E-048$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14: $Vs = 279249.888$

$$Av = 157079.633$$

$$fy = 444.44$$

s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 391586.536
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 391586.536
knl = 1 (zero step-static loading)

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

= 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 = 2.5320539E-012
Vu = 3.1643569E-048
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

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

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

Constant Properties

Knowledge Factor, = 1.00
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
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/lc = 0.30
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.4198E+007$
Shear Force, $V2 = -4692.913$
Shear Force, $V3 = -3.5246242E-013$
Axial Force, $F = -4883.466$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1231.504$
-Compression: $As_c = 829.3805$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 829.3805$
-Compression: $As_{,com} = 829.3805$
-Middle: $As_{,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = u = 0.00601254$
 $u = y + p = 0.00601254$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00601254$ ((4.29), Biskinis Phd)
 $My = 9.7901E+007$
 $Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 3025.481
From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 1.6421E+013$
 $factor = 0.30$
 $Ag = 125000.00$
 $fc' = 20.00$
 $N = 4883.466$
 $Ec * Ig = 5.4737E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{,ten}, y_{,com})$
 $y_{,ten} = 3.8742278E-006$
with ((10.1), ASCE 41-17) $fy = \text{Min}(fy, 1.25 * fy * (lb/ld)^{2/3}) = 248.9644$
 $d = 457.00$
 $y = 0.296918$
 $A = 0.01821006$
 $B = 0.01003951$
with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4883.466$
 $b = 250.00$
 $" = 0.0940919$
 $y_{,comp} = 1.2695211E-005$
with $fc = 20.00$
 $Ec = 21019.039$
 $y = 0.29521167$
 $A = 0.0179136$
 $B = 0.00986782$
with $Es = 200000.00$

Calculation of ratio lb/ld

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of ρ -

From table 10-8: $\rho = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_{yE}/V_{CoIE} = 0.24493996$

$d = 457.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$b_w = 250.00$

The term $2*t_f/b_w*(f_{fe}/f_s)$ is implemented to account for FRP contribution

where $f = 2*t_f/b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe}/f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$NUD = 4883.466$

$A_g = 125000.00$

$f_{cE} = 20.00$

$f_{yE} = f_{yIE} = 0.00$

$\rho = \text{Area_Tot_Long_Rein}/(b*d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 20.00$

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

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

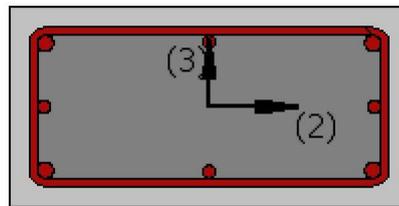
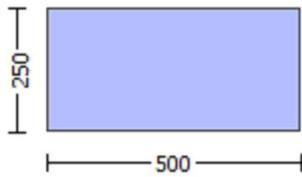
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.4198E+007$

Shear Force, $V_a = -4692.913$

EDGE -B-

Bending Moment, $M_b = 115914.626$

Shear Force, $V_b = 4692.913$

BOTH EDGES

Axial Force, $F = -4883.466$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 0.00$

-Compression: $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 829.3805$

-Compression: $A_{sl,com} = 829.3805$

-Middle: $A_{sl,mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 351944.94$
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col0} = 351944.94$
 $V_{Col} = 351944.94$
 $knl = 1.00$
 $displacement_ductility_demand = 0.22072328$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + \phi * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\phi = 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 115914.626$
 $V_u = 4692.913$
 $d = 0.8 * h = 400.00$
 $N_u = 4883.466$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 251327.412$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{Col} = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 0.00013159$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00059619$ ((4.29), Biskinis Phd)
 $M_y = 9.7901E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.8742278E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9644$
 $d = 457.00$
 $y = 0.296918$
 $A = 0.01821006$
 $B = 0.01003951$
with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4883.466$

b = 250.00
" = 0.0940919
y_comp = 1.2695211E-005
with fc = 20.00
Ec = 21019.039
y = 0.29521167
A = 0.0179136
B = 0.00986782
with Es = 200000.00

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

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

Calculation No. 6

column C1, Floor 1

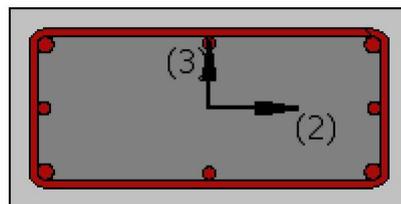
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 5.1679577E-032$

EDGE -B-

Shear Force, $V_b = -5.1679577E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 829.3805$

-Compression: $A_{st, \text{com}} = 829.3805$

-Middle: $A_{st, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.9340E+007$

$M_{u1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.9340E+007$

$M_{u2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$$y_2, sh_2, ft_2, fy_2, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_2 = fs = 311.2056$$

with $E_s = E_s = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $su_v = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.30$
 $su_v = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fs_y = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_y = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $E_s = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(fs_1/f_c) = 0.12468976$
 $2 = A_{sl,com}/(b*d)*(fs_2/f_c) = 0.12468976$
 $v = A_{sl,mid}/(b*d)*(fsv/f_c) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c =$ confinement factor = 1.00
 $1 = A_{sl,ten}/(b*d)*(fs_1/f_c) = 0.16570866$
 $2 = A_{sl,com}/(b*d)*(fs_2/f_c) = 0.16570866$
 $v = A_{sl,mid}/(b*d)*(fsv/f_c) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.25403043$
 $Mu = MR_c (4.14) = 5.9340E+007$
 $u = su (4.1) = 3.3157250E-005$

 Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_1 -

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

$u = 3.3157250E-005$
 $Mu = 5.9340E+007$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

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

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 500.00

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00129669

sh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12468976$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12468976$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.16570866$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.16570866$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

$Mu = MRc$ (4.14) = 5.9340E+007

$u = su$ (4.1) = 3.3157250E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

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

$u = 3.3157250E-005$

$Mu = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0050171$

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

From (5.4b), TBDY: $cu = 0.0050171$

w_e (5.4c) = 0.00143849

ase ((5.4d), TBDY) = 0.05494666

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00314159$

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

 psh_x (5.4d) = 0.00314159

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$bk = 500.00$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00

From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = \text{Asl,ten}/(b*d)*(fs1/fc) = 0.16570866$$

$$2 = \text{Asl,com}/(b*d)*(fs2/fc) = 0.16570866$$

$$v = \text{Asl,mid}/(b*d)*(fsv/fc) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su \text{ (4.9)} = 0.25403043$$

$$Mu = MRc \text{ (4.14)} = 5.9340E+007$$

$$u = su \text{ (4.1)} = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$fc = 20.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } cu = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$psh_{,min} = \text{Min}(psh_x, psh_y) = 0.00314159$$

Expression ((5.4d), TBDY) for $psh_{,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$psh_y \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$f_{y1} = 311.2056$
 $s_{u1} = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $s_{u1} = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{su1,nominal} = 0.08$,
 For calculation of $e_{su1,nominal}$ and y_1, sh_1, ft_1, f_{y1} , it is considered
 characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{s1} = f_s = 311.2056$
 with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $f_{y2} = 311.2056$
 $s_{u2} = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,
 For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, f_{y2} , it is considered
 characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{s2} = f_s = 311.2056$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $f_{yv} = 311.2056$
 $s_{uv} = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,
 considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, f_{yv} , it is considered
 characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 311.2056$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.12468976$
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.12468976$
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.16570866$
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.16570866$
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $s_u (4.9) = 0.25403043$
 $M_u = M_{Rc} (4.14) = 5.9340E+007$
 $u = s_u (4.1) = 3.3157250E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 251961.592$

Calculation of Shear Strength at edge 1, $V_{r1} = 251961.592$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l V_{Col0}$

$V_{Col0} = 251961.592$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f^* V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 3.4623283E-012$

$V_u = 5.1679577E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 251961.592$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n l V_{Col0}$

$V_{Col0} = 251961.592$

$k_n l = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f^* V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 3.4623283E-012$

$V_u = 5.1679577E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

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

At local axis: 3

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

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

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, $f_s = 1.25 * f_{sm} = 555.55$

Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -3.1643569E-048$
EDGE -B-
Shear Force, $V_b = 3.1643569E-048$
BOTH EDGES
Axial Force, $F = -4666.932$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{st,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.24493996$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.4387E+008$
 $M_{u1+} = 1.4387E+008$, 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
 $M_{u1-} = 1.4387E+008$, 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
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.4387E+008$

$\mu_{2+} = 1.4387E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 1.4387E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

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

$$\mu = 1.4115955E-005$$

$$\mu_{1+} = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} \text{ (5.4d)} = 0.00314159$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

 $p_{sh,y} \text{ (5.4d)} = 0.00628319$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

 $s = 100.00$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft2 = 373.4467$$

$$fy2 = 311.2056$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and $y2$, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$y1$, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs2 = fs = 311.2056$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv , shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y1$, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

---->

$$su (4.9) = 0.20632353$$

$$Mu = MRc (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

$$u = 1.4115955E-005$$

$$Mu = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e (5.4c) = 0.00143849$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_2 = fs = 311.2056$$

with $E_s = E_s = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.11295746$
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.11295746$
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.05476725$

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.15907051$
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.15907051$
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.07712509$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20632353$
 $Mu = MRc (4.14) = 1.4387E+008$
 $u = su (4.1) = 1.4115955E-005$

 Calculation of ratio lb/ld

 Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Mu_{2+}

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

$u = 1.4115955E-005$
 $Mu = 1.4387E+008$

 with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$

$$ase((5.4d), TBDY) = 0.05494666$$

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$$

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

$$psh,x(5.4d) = 0.00314159$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 500.00$$

$$psh,y(5.4d) = 0.00628319$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 555.55$$

$$fce = 20.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00129669$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4467$$

$$fy1 = 311.2056$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1_nominal((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs1 = fs = 311.2056$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00129669$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4467$$

$$fy2 = 311.2056$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2_nominal((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs2 = fs = 311.2056$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv_nominal((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_nominal = 0.08,$$

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11295746$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11295746$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05476725$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15907051$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15907051$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07712509$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20632353

$\mu_u = MR_c$ (4.14) = 1.4387E+008

$u = su$ (4.1) = 1.4115955E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

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

$u = 1.4115955E-005$

$\mu_u = 1.4387E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

cc (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0050171$

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

From (5.4b), TBDY: $cu = 0.0050171$

w_e (5.4c) = 0.00143849

ase ((5.4d), TBDY) = 0.05494666

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00314159$

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

 psh_x (5.4d) = 0.00314159

$A_{stir} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$bk = 500.00$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00

From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814

ft2 = 373.4467
fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814

ftv = 373.4467
fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u \text{ (4.9)} = 0.20632353$$

$$M_u = M_{Rc} \text{ (4.14)} = 1.4387E+008$$

$$u = s_u \text{ (4.1)} = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 391586.536$

Calculation of Shear Strength at edge 1, $V_{r1} = 391586.536$

$$V_{r1} = V_{CoI} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 391586.536$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.5320539E-012$$

$$V_u = 3.1643569E-048$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 279249.888$$

$$A_v = 157079.633$$

$$f_y = 444.44$$

$$s = 100.00$$

$$V_s \text{ is multiplied by } \text{Col} = 1.00$$

$$s/d = 0.25$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 297085.704$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 391586.536$

$$V_{r2} = V_{CoI} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 391586.536$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.5320539E-012$$

$$V_u = 3.1643569E-048$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

From (11.5.4.8), ACI 318-14: $V_s = 279249.888$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 100.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $b_w = 250.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$
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, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 6.1234342E-011$
Shear Force, $V_2 = 4692.913$
Shear Force, $V_3 = 3.5246242E-013$
Axial Force, $F = -4883.466$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{st,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_bL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = * u = 0.00531685$
 $u = y + p = 0.00531685$

- Calculation of γ -

$$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00531685 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 4.3654E+007$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 4.1053E+012$$

$$\text{factor} = 0.30$$

$$A_g = 125000.00$$

$$f_c' = 20.00$$

$$N = 4883.466$$

$$E_c * I_g = 1.3684E+013$$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$$\gamma = \text{Min}(\gamma_{ten}, \gamma_{com})$$

$$\gamma_{ten} = 8.9408280E-006$$

$$\text{with ((10.1), ASCE 41-17) } \gamma_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9644$$

$$d = 207.00$$

$$\gamma = 0.32739632$$

$$A = 0.02010145$$

$$B = 0.01221363$$

$$\text{with } p_t = 0.00801334$$

$$p_c = 0.00801334$$

$$p_v = 0.00388525$$

$$N = 4883.466$$

$$b = 500.00$$

$$" = 0.20772947$$

$$\gamma_{comp} = 2.5390422E-005$$

$$\text{with } f_c = 20.00$$

$$E_c = 21019.039$$

$$\gamma = 0.32587375$$

$$A = 0.01977419$$

$$B = 0.01202411$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b / I_d \geq 1$

$$\text{shear control ratio } V_y E / V_{col} E = 0.15700689$$

$$d = 207.00$$

$$s = 0.00$$

$$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$b_w = 500.00$$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$$N_{UD} = 4883.466$$

$$A_g = 125000.00$$

$$f_c E = 20.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

$$p_l = \text{Area}_{Tot_Long_Rein} / (b * d) = 0.01991193$$

$$b = 500.00$$

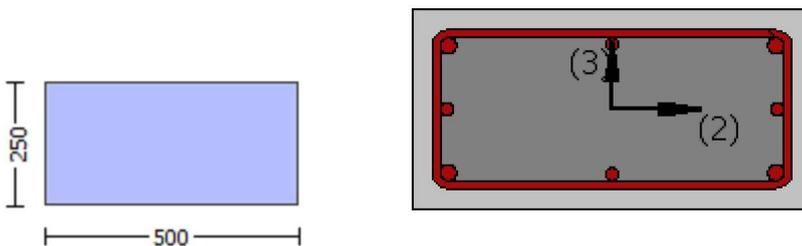
$$d = 207.00$$

$f_{cE} = 20.00$

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

Calculation No. 7

column C1, Floor 1
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity V_{Rd}
Edge: End
Local Axis: (3)



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

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$
 #####
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$
 No FRP Wrapping

 Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 9.9715419E-010$
 Shear Force, $V_a = -3.5246242E-013$
 EDGE -B-
 Bending Moment, $M_b = 6.1234342E-011$
 Shear Force, $V_b = 3.5246242E-013$
 BOTH EDGES
 Axial Force, $F = -4883.466$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 829.3805$
 -Compression: $A_{sc,com} = 829.3805$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

 Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 226281.233$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 226281.233$
 $V_{CoI} = 226281.233$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

 NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs ((11.3), ACI 440).

 $= 1$ (normal-weight concrete)
 $f'_c = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa ((22.5.3.1), ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 6.1234342E-011$
 $V_u = 3.5246242E-013$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4883.466$
 $Ag = 125000.00$
 From ((11.5.4.8), ACI 318-14: $V_s = 125663.706$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From ((11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 500.00$

 $displacement_ductility_demand$ is calculated as / y

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

From analysis, chord rotation $\theta = 3.1859708E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00531685$ ((4.29), Biskinis Phd))
 $M_y = 4.3654E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 8.9408280E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b / l_d)^{2/3}) = 248.9644$
 $d = 207.00$
 $y = 0.32739632$
 $A = 0.02010145$
 $B = 0.01221363$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4883.466$
 $b = 500.00$
 $\phi = 0.20772947$
 $y_{comp} = 2.5390422E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32587375$
 $A = 0.01977419$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

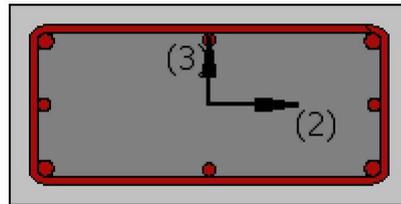
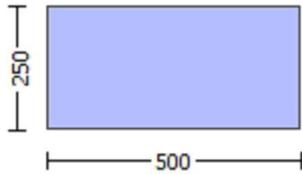
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 5.1679577E-032$

EDGE -B-

Shear Force, $V_b = -5.1679577E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{ten} = 829.3805$

-Compression: $As_{com} = 829.3805$

-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.9340E+007$

$M_{u1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.9340E+007$

$M_{u2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ϕ_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0050171$

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

From (5.4b), TBDY: $\phi_{cu} = 0.0050171$

ϕ_{we} (5.4c) = 0.00143849

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{psh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{psh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Es_v = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.12468976$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.12468976$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.16570866$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.16570866$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.25403043$$

$$M_u = M_{Rc}(4.14) = 5.9340E+007$$

$$u = s_u(4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u1} -

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

$$u = 3.3157250E-005$$

$$M_u = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866

2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866

v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vsy2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

Mu = MRc (4.14) = 5.9340E+007

u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 3.3157250E-005$$

$$\mu_u = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.12468976$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12468976$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.16570866$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.16570866$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e (5.4c) = 0.00143849$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$y_2, sh_2, f_{t2}, f_{y2}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Es = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.12468976$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.12468976$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.16570866$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.16570866$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 251961.592$

Calculation of Shear Strength at edge 1, Vr1 = 251961.592

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VCol0$$

$$VCol0 = 251961.592$$

$$knl = 1 \text{ (zero step-static loading)}$$

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

= 1 (normal-weight concrete)

$$fc' = 20.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 3.4623283E-012$$

$$Vu = 5.1679577E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14: $Vs = 139624.944$

$$Av = 157079.633$$

$$fy = 444.44$$

s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 251961.592
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 251961.592
knl = 1 (zero step-static loading)

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

= 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 = 3.4623283E-012
Vu = 5.1679577E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

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

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

Constant Properties

Knowledge Factor, = 1.00
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

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -3.1643569E-048$
EDGE -B-
Shear Force, $V_b = 3.1643569E-048$
BOTH EDGES
Axial Force, $F = -4666.932$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 829.3805$
-Compression: $As_{,com} = 829.3805$
-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.24493996$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.4387E+008$
 $Mu_{1+} = 1.4387E+008$, 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
 $Mu_{1-} = 1.4387E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.4387E+008$
 $Mu_{2+} = 1.4387E+008$, 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
 $Mu_{2-} = 1.4387E+008$, 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 Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.4115955E-005$
 $Mu = 1.4387E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.0050171$
 $\phi_{we} (5.4c) = 0.00143849$
 $\phi_{ase} ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$$

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

$$psh,x (5.4d) = 0.00314159$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 500.00$$

$$psh,y (5.4d) = 0.00628319$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 555.55$$

$$fce = 20.00$$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00129669$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4467$$

$$fy1 = 311.2056$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs1 = fs = 311.2056$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00129669$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4467$$

$$fy2 = 311.2056$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs2 = fs = 311.2056$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered

characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

with $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11295746$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11295746$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

c = confinement factor = 1.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.20632353$$

$$\mu_u = M_{Rc} (4.14) = 1.4387E+008$$

$$u = s_u (4.1) = 1.4115955E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{u1} -

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e (5.4c) = 0.00143849$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 250.00$$

$s = 100.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.11295746$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.11295746$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.15907051$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.15907051$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.20632353$$

$$\mu = M_{Rc}(4.14) = 1.4387E+008$$

$$u = s_u(4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$u = 1.4115955E-005$$

$$\mu = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051

2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20632353

Mu = MRc (4.14) = 1.4387E+008

u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2 -

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

$$\mu = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.11295746$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.11295746$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.15907051$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.15907051$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < vs, y_2$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20632353$$

$$\mu = MRc (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 391586.536$

Calculation of Shear Strength at edge 1, $V_{r1} = 391586.536$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$$

$$V_{Col0} = 391586.536$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * fy * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '

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

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.5320539E-012$

$V_u = 3.1643569E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 279249.888$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 391586.536$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I \cdot V_{Col0}$

$V_{Col0} = 391586.536$

$k_n = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.5320539E-012$

$V_u = 3.1643569E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 279249.888$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 250.00$

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

At local axis: 2

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

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 115914.626$
Shear Force, $V_2 = 4692.913$
Shear Force, $V_3 = 3.5246242E-013$
Axial Force, $F = -4883.466$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 829.3805$
-Compression: $A_{s,com} = 829.3805$
-Middle: $A_{s,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_bL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.00059619$
 $u = y + p = 0.00059619$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00059619$ ((4.29), Biskinis Phd))
 $M_y = 9.7901E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.8742278E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 248.9644$
 $d = 457.00$
 $y = 0.296918$
 $A = 0.01821006$
 $B = 0.01003951$
with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4883.466$
 $b = 250.00$

" = 0.0940919
y_comp = 1.2695211E-005
with fc = 20.00
Ec = 21019.039
y = 0.29521167
A = 0.0179136
B = 0.00986782
with Es = 200000.00

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

- Calculation of p -

From table 10-8: p = 0.00

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1
shear control ratio $V_y E / V_{col} O E = 0.24493996$

d = 457.00

s = 0.00

t = $A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$b_w = 250.00$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

NUD = 4883.466

Ag = 125000.00

f_{cE} = 20.00

f_{yE} = f_{yE} = 0.00

$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.01803838$

b = 250.00

d = 457.00

f_{cE} = 20.00

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

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

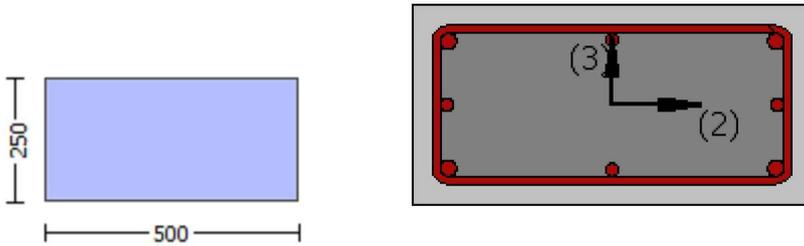
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.1758E+007$

Shear Force, $V_a = -3886.204$
EDGE -B-
Bending Moment, $M_b = 95988.968$
Shear Force, $V_b = 3886.204$
BOTH EDGES
Axial Force, $F = -4846.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 1231.504$
-Compression: $A_{sl,c} = 829.3805$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 829.3805$
-Compression: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 301632.49$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 301632.49$
 $V_{CoI} = 301632.49$
 $k_n = 1.00$
displacement_ductility_demand = 0.03365955

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1.1758E+007$
 $V_u = 3886.204$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4846.244$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 251327.412$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{CoI} = 1.00$
 $s/d = 0.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 250.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation = 0.00020237
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00601212$ ((4.29), Biskinis Phd)
 $M_y = 9.7894E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3025.481
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.6421E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4846.244$
 $E_c \cdot I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 3.8741252\text{E-}006$
with $((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 248.9644$
 $d = 457.00$
 $y = 0.29689938$
 $A = 0.01820876$
 $B = 0.0100382$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4846.244$
 $b = 250.00$
 $" = 0.0940919$
 $y_{\text{comp}} = 1.2695458\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.29520593$
 $A = 0.01791455$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

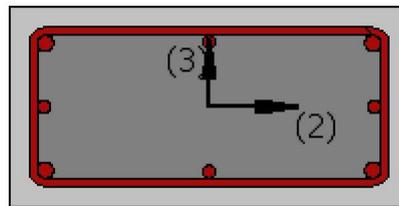
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$

 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, $f_s = 1.25 \cdot f_{sm} = 555.55$

 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 5.1679577E-032$
 EDGE -B-
 Shear Force, $V_b = -5.1679577E-032$
 BOTH EDGES
 Axial Force, $F = -4666.932$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 829.3805$
 -Compression: $A_{sl,com} = 829.3805$
 -Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 5.9340E+007$

$M_{u1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 5.9340E+007$

$M_{u2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

α (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$

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

From (5.4b), TBDY: $\phi_u = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x} , \phi_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $\phi_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

From ((5.A5), TBDY), TBDY: $\phi_c = 0.002$

c = confinement factor = 1.00

$y_1 = 0.00129669$

$sh_1 = 0.0044814$

$ft_1 = 373.4467$

$fy_1 = 311.2056$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866

2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866

v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

Mu = MRc (4.14) = 5.9340E+007

u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_1 -

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

$$\mu = 3.3157250E-005$$

$$\mu_1 = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.12468976$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12468976$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.16570866$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.16570866$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0050171$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.0050171$
we (5.4c) = 0.00143849
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.00314159
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: $cc = 0.002$
c = confinement factor = 1.00
y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lou,min = lb/d = 0.30$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu1_nominal = 0.08$,
For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs1 = fs = 311.2056$
with $Es1 = Es = 200000.00$

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 0.30$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs2 = fs = 311.2056$
with $Es2 = Es = 200000.00$
yv = 0.00129669

$shv = 0.0044814$
 $ftv = 373.4467$
 $fyv = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.25403043$
 $Mu = MRc (4.14) = 5.9340E+007$
 $u = su (4.1) = 3.3157250E-005$

 Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu2$ -

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

$u = 3.3157250E-005$
 $Mu = 5.9340E+007$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

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

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 500.00

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00129669

sh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y2, sh2,ft2,fy2, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12468976$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12468976$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 20.00$

$cc \text{ (5A.5, TBDY)} = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.16570866$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.16570866$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.25403043$

$Mu = MRc \text{ (4.14)} = 5.9340E+007$

$u = su \text{ (4.1)} = 3.3157250E-005$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 251961.592$

Calculation of Shear Strength at edge 1, $V_{r1} = 251961.592$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$Mu = 3.4623283E-012$

$Vu = 5.1679577E-032$

$d = 0.8 \cdot h = 200.00$

$Nu = 4666.932$

$Ag = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 251961.592$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.4623283E-012$

$V_u = 5.1679577E-032$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $\text{Col} = 1.00$

$s/d = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$b_w = 500.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -3.1643569E-048$

EDGE -B-

Shear Force, $V_b = 3.1643569E-048$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{,ten} = 829.3805$

-Compression: $As_{,com} = 829.3805$

-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.24493996$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4387E+008$

$Mu_{1+} = 1.4387E+008$, 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

$Mu_{1-} = 1.4387E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4387E+008$

$Mu_{2+} = 1.4387E+008$, 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

$Mu_{2-} = 1.4387E+008$, 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 Mu_{1+}

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

$\phi_u = 1.4115955E-005$

$M_u = 1.4387E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$

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

From (5.4b), TBDY: $\phi_u = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$p_{sh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.11295746$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.11295746$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.15907051$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.15907051$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.20632353$$

$$\mu = M_{Rc}(4.14) = 1.4387E+008$$

$$u = s_u(4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_1 -

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

$$u = 1.4115955E-005$$

$$\mu = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051

2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20632353

Mu = MRc (4.14) = 1.4387E+008

u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_2_{nominal} = 0.08$,

For calculation of $esu_2_{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.11295746$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.11295746$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20632353$$

$$\mu_u = MR_c (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2}

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

b = 250.00
 d = 457.00
 d' = 43.00
 v = 0.00204242
 N = 4666.932
 fc = 20.00
 co (5A.5, TBDY) = 0.002
 Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 we (5.4c) = 0.00143849
 ase ((5.4d), TBDY) = 0.05494666
 bo = 440.00
 ho = 190.00
 bi2 = 459400.00
 psh,min = $\text{Min}(psh,x, psh,y) = 0.00314159$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 psh,x (5.4d) = 0.00314159
 Ash = $\text{Astir} * ns = 78.53982$
 No stirrups, ns = 2.00
 bk = 500.00

 psh,y (5.4d) = 0.00628319
 Ash = $\text{Astir} * ns = 78.53982$
 No stirrups, ns = 2.00
 bk = 250.00

 s = 100.00
 fywe = 555.55
 fce = 20.00
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 c = confinement factor = 1.00
 y1 = 0.00129669
 sh1 = 0.0044814
 ft1 = 373.4467
 fy1 = 311.2056
 su1 = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/d = 0.30$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 311.2056$
 with $Es1 = Es = 200000.00$
 y2 = 0.00129669
 sh2 = 0.0044814
 ft2 = 373.4467
 fy2 = 311.2056
 su2 = 0.00512
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 0.30$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 311.2056$
 with $Es2 = Es = 200000.00$
 yv = 0.00129669

$shv = 0.0044814$
 $ftv = 373.4467$
 $fyv = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20632353$
 $Mu = MRc (4.14) = 1.4387E+008$
 $u = su (4.1) = 1.4115955E-005$

 Calculation of ratio lb/ld

 Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Shear Strength $Vr = Min(Vr1,Vr2) = 391586.536$

Calculation of Shear Strength at edge 1, $Vr1 = 391586.536$
 $Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$
 $VColO = 391586.536$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 2.5320539E-012$
 $Vu = 3.1643569E-048$
 $d = 0.8*h = 400.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $Vs = 279249.888$
 $Av = 157079.633$
 $fy = 444.44$

s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 391586.536
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 391586.536
knl = 1 (zero step-static loading)

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

= 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 = 2.5320539E-012
Vu = 3.1643569E-048
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

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

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

Constant Properties

Knowledge Factor, = 1.00
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
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 8.2514878E-010$

Shear Force, $V2 = -3886.204$

Shear Force, $V3 = -2.9187433E-013$

Axial Force, $F = -4846.244$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1231.504$

-Compression: $As_c = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{,ten} = 829.3805$

-Compression: $As_{,com} = 829.3805$

-Middle: $As_{,mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = * u = 0.025916$
 $u = y + p = 0.025916$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00531645$ ((4.29), Biskinis Phd))

$My = 4.3651E+007$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 4.1053E+012$

factor = 0.30

$Ag = 125000.00$

$fc' = 20.00$

$N = 4846.244$

$Ec * Ig = 1.3684E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 8.9405911E-006$

with ((10.1), ASCE 41-17) $fy = \text{Min}(fy, 1.25 * fy * (lb/d)^{2/3}) = 248.9644$

$d = 207.00$

$y = 0.3273785$

$A = 0.0201$

$B = 0.01221219$

with $pt = 0.00801334$

$pc = 0.00801334$

$pv = 0.00388525$

$N = 4846.244$

$b = 500.00$

$" = 0.20772947$

$y_{comp} = 2.5390916E-005$

with $fc = 20.00$

$Ec = 21019.039$

$y = 0.32586742$

$A = 0.01977524$

$B = 0.01202411$

with $Es = 200000.00$

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of ρ -

From table 10-8: $\rho = 0.02059956$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_{yE}/V_{CoIE} = 0.15700689$

$d = 207.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$b_w = 500.00$

The term $2*t_f/b_w*(f_{fe}/f_s)$ is implemented to account for FRP contribution

where $f = 2*t_f/b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe}/f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4846.244$

$A_g = 125000.00$

$f_{cE} = 20.00$

$f_{ytE} = f_{ylE} = 0.00$

$\rho_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 20.00$

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

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

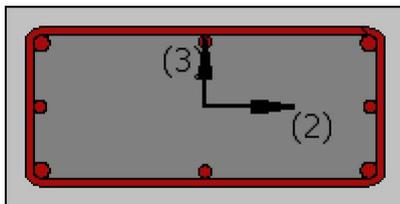
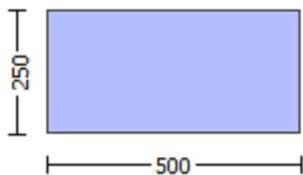
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 8.2514878E-010$

Shear Force, $V_a = -2.9187433E-013$

EDGE -B-

Bending Moment, $M_b = 5.1303366E-011$

Shear Force, $V_b = 2.9187433E-013$

BOTH EDGES

Axial Force, $F = -4846.244$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 1231.504$

-Compression: $A_{sc} = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 829.3805$

-Compression: $A_{sl,com} = 829.3805$

-Middle: $A_{sl,mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 226273.861$
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col0} = 226273.861$
 $V_{Col} = 226273.861$
 $knl = 1.00$
 $displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + \phi * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

$\phi = 1$ (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 8.2514878E-010$
 $V_u = 2.9187433E-013$
 $d = 0.8 * h = 200.00$
 $N_u = 4846.244$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 125663.706$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{Col} = 1.00$
 $s/d = 0.50$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 500.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 5.5099430E-020$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00531645$ ((4.29), Biskinis Phd)
 $M_y = 4.3651E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4846.244$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 8.9405911E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9644$
 $d = 207.00$
 $y = 0.3273785$
 $A = 0.0201$
 $B = 0.01221219$
with $pt = 0.00801334$
 $pc = 0.00801334$
 $pv = 0.00388525$
 $N = 4846.244$

b = 500.00
" = 0.20772947
y_comp = 2.5390916E-005
with fc = 20.00
Ec = 21019.039
y = 0.32586742
A = 0.01977524
B = 0.01202411
with Es = 200000.00

Calculation of ratio I_b/I_d

Inadequate Lap Length with $I_b/I_d = 0.30$

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

Calculation No. 12

column C1, Floor 1

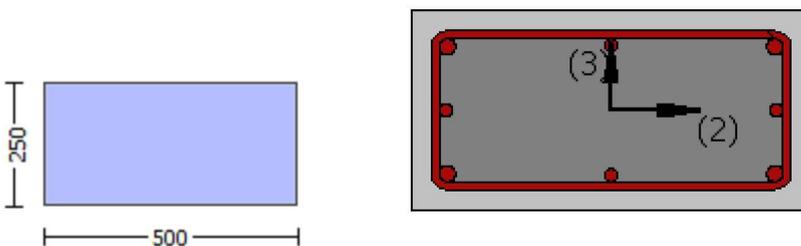
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,u,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 5.1679577E-032$

EDGE -B-

Shear Force, $V_b = -5.1679577E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 829.3805$

-Compression: $A_{st,com} = 829.3805$

-Middle: $A_{st,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 5.9340E+007$

$\mu_{1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 5.9340E+007$

$\mu_{2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$\mu_{2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of μ_{1+}

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

$\mu = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_2 = fs = 311.2056$$

with $E_s = E_s = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_y = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_y = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $E_s = E_s = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.12468976$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.12468976$
 $v = A_{sl,mid}/(b * d) * (fsv/f_c) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.16570866$
 $2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.16570866$
 $v = A_{sl,mid}/(b * d) * (fsv/f_c) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$u = 3.3157250E-005$

$\mu_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

$cc (5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.0050171$

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

From (5.4b), TBDY: $\mu_u = 0.0050171$

$w_e (5.4c) = 0.00143849$

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

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

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 500.00

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00129669

sh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12468976$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12468976$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.16570866$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.16570866$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

$Mu = MRc$ (4.14) = 5.9340E+007

$u = su$ (4.1) = 3.3157250E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

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

$u = 3.3157250E-005$

$Mu = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0050171$

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

From (5.4b), TBDY: $cu = 0.0050171$

w_e (5.4c) = 0.00143849

ase ((5.4d), TBDY) = 0.05494666

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$

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

 psh,x (5.4d) = 0.00314159

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$bk = 500.00$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00

From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = \text{Asl,ten}/(b*d)*(fs1/fc) = 0.16570866$$

$$2 = \text{Asl,com}/(b*d)*(fs2/fc) = 0.16570866$$

$$v = \text{Asl,mid}/(b*d)*(fsv/fc) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su \text{ (4.9)} = 0.25403043$$

$$Mu = MRc \text{ (4.14)} = 5.9340E+007$$

$$u = su \text{ (4.1)} = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$fc = 20.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } cu = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$psh_{,min} = \text{Min}(psh,x, psh,y) = 0.00314159$$

Expression ((5.4d), TBDY) for $psh_{,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh,x \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir}*n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$psh,y \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir}*n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$f_{y1} = 311.2056$
 $s_{u1} = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $s_{u1} = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{su1,nominal} = 0.08$,
 For calculation of $e_{su1,nominal}$ and y_1, sh_1, ft_1, f_{y1} , it is considered
 characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{s1} = f_s = 311.2056$
 with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $f_{y2} = 311.2056$
 $s_{u2} = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,
 For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, f_{y2} , it is considered
 characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, f_{y2} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{s2} = f_s = 311.2056$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $f_{yv} = 311.2056$
 $s_{uv} = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.30$
 $s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,
 considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, f_{yv} , it is considered
 characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 311.2056$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.12468976$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.12468976$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.16570866$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.16570866$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $s_u (4.9) = 0.25403043$
 $M_u = M_{Rc} (4.14) = 5.9340E+007$
 $u = s_u (4.1) = 3.3157250E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 251961.592$

Calculation of Shear Strength at edge 1, $V_{r1} = 251961.592$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$V_{Col0} = 251961.592$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 3.4623283E-012$

$V_u = 5.1679577E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 251961.592$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$V_{Col0} = 251961.592$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 3.4623283E-012$

$V_u = 5.1679577E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

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

At local axis: 3

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

At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcrs

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

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, $f_s = 1.25 * f_{sm} = 555.55$

Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$

Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -3.1643569E-048$
EDGE -B-
Shear Force, $V_b = 3.1643569E-048$
BOTH EDGES
Axial Force, $F = -4666.932$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 829.3805$
-Compression: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.24493996$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.4387E+008$
 $M_{u1+} = 1.4387E+008$, 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
 $M_{u1-} = 1.4387E+008$, 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
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.4387E+008$

$\mu_{2+} = 1.4387E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 1.4387E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

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

$$\mu = 1.4115955E-005$$

$$\mu_{1+} = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} \text{ (5.4d)} = 0.00314159$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

 $p_{sh,y} \text{ (5.4d)} = 0.00628319$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

 $s = 100.00$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft2 = 373.4467$$

$$fy2 = 311.2056$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and $y2$, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$y1$, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs2 = fs = 311.2056$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv , shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y1$, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$ - LHS eq.(4.5) is satisfied

---->

$$su (4.9) = 0.20632353$$

$$Mu = MRc (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

$$u = 1.4115955E-005$$

$$Mu = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e (5.4c) = 0.00143849$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, f_{t1}, f_{y1}, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs_2 = fs = 311.2056$$

with $E_s = E_s = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $su_v = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.30$
 $su_v = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(fs_1/fc) = 0.11295746$
 $2 = A_{sl,com}/(b*d)*(fs_2/fc) = 0.11295746$
 $v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c =$ confinement factor = 1.00
 $1 = A_{sl,ten}/(b*d)*(fs_1/fc) = 0.15907051$
 $2 = A_{sl,com}/(b*d)*(fs_2/fc) = 0.15907051$
 $v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.07712509$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$su (4.9) = 0.20632353$
 $Mu = MRc (4.14) = 1.4387E+008$
 $u = su (4.1) = 1.4115955E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

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

$u = 1.4115955E-005$
 $Mu = 1.4387E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

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

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 500.00

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00129669

sh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11295746$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11295746$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05476725$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15907051$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15907051$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07712509$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20632353

$\mu_u = MR_c$ (4.14) = 1.4387E+008

$u = su$ (4.1) = 1.4115955E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

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

$u = 1.4115955E-005$

$\mu_u = 1.4387E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

cc (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.0050171$

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

From (5.4b), TBDY: $cu = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 555.55
fce = 20.00
From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00129669
sh1 = 0.0044814
ft1 = 373.4467
fy1 = 311.2056
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669
sh2 = 0.0044814
ft2 = 373.4467
fy2 = 311.2056
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669
shv = 0.0044814
ftv = 373.4467
fyv = 311.2056
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su \text{ (4.9)} = 0.20632353$$

$$Mu = MRc \text{ (4.14)} = 1.4387E+008$$

$$u = su \text{ (4.1)} = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 391586.536$

Calculation of Shear Strength at edge 1, $V_{r1} = 391586.536$

$$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl * V_{Col0}$$

$$V_{Col0} = 391586.536$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 2.5320539E-012$$

$$Vu = 3.1643569E-048$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 279249.888$$

$$A_v = 157079.633$$

$$f_y = 444.44$$

$$s = 100.00$$

$$V_s \text{ is multiplied by } Col = 1.00$$

$$s/d = 0.25$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 297085.704$$

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 391586.536$

$$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl * V_{Col0}$$

$$V_{Col0} = 391586.536$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 2.5320539E-012$$

$$Vu = 3.1643569E-048$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14: $V_s = 279249.888$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 100.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $b_w = 250.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$
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, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.1758E+007$
Shear Force, $V_2 = -3886.204$
Shear Force, $V_3 = -2.9187433E-013$
Axial Force, $F = -4846.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 1231.504$
-Compression: $A_{sc} = 829.3805$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{sc,com} = 829.3805$
-Middle: $A_{s,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.03601212$
 $u = y + p = 0.03601212$

- Calculation of γ -

$$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00601212 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 9.7894E+007$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3025.481$$

$$\text{From table 10.5, ASCE 41-17: } E_{eff} = \text{factor} * E_c * I_g = 1.6421E+013$$

$$\text{factor} = 0.30$$

$$A_g = 125000.00$$

$$f_c' = 20.00$$

$$N = 4846.244$$

$$E_c * I_g = 5.4737E+013$$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$$\gamma = \text{Min}(\gamma_{ten}, \gamma_{com})$$

$$\gamma_{ten} = 3.8741252E-006$$

$$\text{with ((10.1), ASCE 41-17) } \gamma_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 248.9644$$

$$d = 457.00$$

$$\gamma = 0.29689938$$

$$A = 0.01820876$$

$$B = 0.0100382$$

$$\text{with } p_t = 0.00725935$$

$$p_c = 0.00725935$$

$$p_v = 0.00351968$$

$$N = 4846.244$$

$$b = 250.00$$

$$" = 0.0940919$$

$$\gamma_{comp} = 1.2695458E-005$$

$$\text{with } f_c = 20.00$$

$$E_c = 21019.039$$

$$\gamma = 0.29520593$$

$$A = 0.01791455$$

$$B = 0.00986782$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b / I_d \geq 1$

$$\text{shear control ratio } V_y E / V_{col} E = 0.24493996$$

$$d = 457.00$$

$$s = 0.00$$

$$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$b_w = 250.00$$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$$N_{UD} = 4846.244$$

$$A_g = 125000.00$$

$$f_c E = 20.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

$$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b * d) = 0.01803838$$

$$b = 250.00$$

$$d = 457.00$$

$f_{cE} = 20.00$

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

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

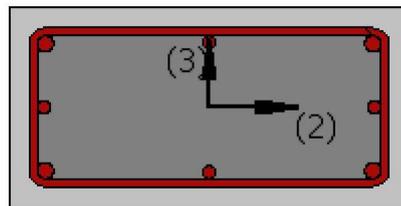
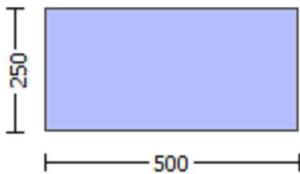
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.1758E+007$
Shear Force, $V_a = -3886.204$
EDGE -B-
Bending Moment, $M_b = 95988.968$
Shear Force, $V_b = 3886.204$
BOTH EDGES
Axial Force, $F = -4846.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{sc,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 351937.567$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{col} = 351937.567$
 $V_{col} = 351937.567$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.18279391$

NOTE: In expression (10-3) ' $V_s = A_v \phi f_y d/s$ ' is replaced by ' $V_s + \phi V_f$ '
where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 95988.968$
 $V_u = 3886.204$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4846.244$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 251327.412$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{col} = 1.00$
 $s/d = 0.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 250.00$

displacement_ductility_demand is calculated as / y

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

From analysis, chord rotation $\theta = 0.00010897$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00059615$ ((4.29), Biskinis Phd))
 $M_y = 9.7894E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.6421E+013$
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4846.244
 $E_c \cdot I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.8741252E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 248.9644$
d = 457.00
y = 0.29689938
A = 0.01820876
B = 0.0100382
with pt = 0.00725935
pc = 0.00725935
pv = 0.00351968
N = 4846.244
b = 250.00
" = 0.0940919
 $y_{comp} = 1.2695458E-005$
with fc = 20.00
Ec = 21019.039
y = 0.29520593
A = 0.01791455
B = 0.00986782
with Es = 200000.00

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

Calculation No. 14

column C1, Floor 1

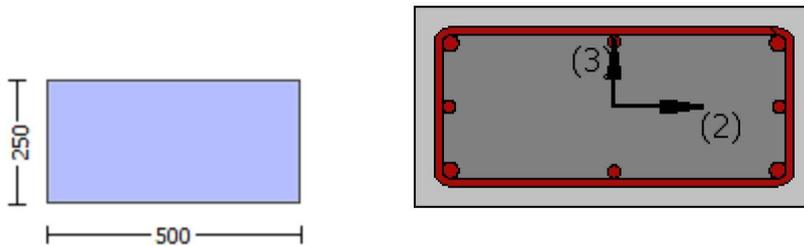
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 5.1679577E-032$

EDGE -B-

Shear Force, $V_b = -5.1679577E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{,ten} = 829.3805$

-Compression: $As_{,com} = 829.3805$

-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.9340E+007$

$Mu_{1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.9340E+007$

$Mu_{2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_{cc}) = 0.0050171$

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

From (5.4b), TBDY: $\phi_{cu} = 0.0050171$

ϕ_{we} (5.4c) = 0.00143849

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{psh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{psh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.12468976$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.12468976$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.16570866$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.16570866$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.25403043$$

$$\mu_u = M_{Rc}(4.14) = 5.9340E+007$$

$$u = s_u(4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$$u = 3.3157250E-005$$

$$\mu_u = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866

2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866

v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vsy2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

Mu = MRc (4.14) = 5.9340E+007

u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 3.3157250E-005$$

$$\mu_{2+} = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.12468976$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12468976$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.16570866$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.16570866$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$f_{t1} = 373.4467$$

$$f_{y1} = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu1_{nominal}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$f_{t2} = 373.4467$$

$$f_{y2} = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu2_{nominal}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$y_2, sh_2, f_{t2}, f_{y2}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00129669$$

$shv = 0.0044814$
 $ftv = 373.4467$
 $fyv = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.25403043$
 $Mu = MRc (4.14) = 5.9340E+007$
 $u = su (4.1) = 3.3157250E-005$

 Calculation of ratio lb/ld

 Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Shear Strength $Vr = Min(Vr1,Vr2) = 251961.592$

Calculation of Shear Strength at edge 1, $Vr1 = 251961.592$
 $Vr1 = VCol ((10.3), ASCE 41-17) = knl * VCol0$
 $VCol0 = 251961.592$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 3.4623283E-012$
 $Vu = 5.1679577E-032$
 $d = 0.8*h = 200.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $Vs = 139624.944$
 $Av = 157079.633$
 $fy = 444.44$

s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 251961.592
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 251961.592
knl = 1 (zero step-static loading)

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

= 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 = 3.4623283E-012
Vu = 5.1679577E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 139624.944
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.50
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

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

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

Constant Properties

Knowledge Factor, = 1.00
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

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -3.1643569E-048$
EDGE -B-
Shear Force, $V_b = 3.1643569E-048$
BOTH EDGES
Axial Force, $F = -4666.932$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{,ten} = 829.3805$
-Compression: $As_{,com} = 829.3805$
-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.24493996$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.4387E+008$
 $Mu_{1+} = 1.4387E+008$, 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
 $Mu_{1-} = 1.4387E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.4387E+008$
 $Mu_{2+} = 1.4387E+008$, 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
 $Mu_{2-} = 1.4387E+008$, 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 Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.4115955E-005$
 $Mu = 1.4387E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.0050171$
 $\phi_{we} (5.4c) = 0.00143849$
 $\phi_{ase} ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$$

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

$$psh,x (5.4d) = 0.00314159$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 500.00$$

$$psh,y (5.4d) = 0.00628319$$

$$Ash = Astir*ns = 78.53982$$

$$\text{No stirrups, } ns = 2.00$$

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 555.55$$

$$fce = 20.00$$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00129669$$

$$sh1 = 0.0044814$$

$$ft1 = 373.4467$$

$$fy1 = 311.2056$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs1 = fs = 311.2056$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00129669$$

$$sh2 = 0.0044814$$

$$ft2 = 373.4467$$

$$fy2 = 311.2056$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs2 = fs = 311.2056$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_nominal = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

with $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11295746$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11295746$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

c = confinement factor = 1.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.20632353$$

$$\mu_u = M_{Rc} (4.14) = 1.4387E+008$$

$$u = s_u (4.1) = 1.4115955E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_{u1} -

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e (5.4c) = 0.00143849$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 250.00$$

$s = 100.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.11295746$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.11295746$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.15907051$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.15907051$

$$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s, y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.20632353$$

$$\mu_u = M_{Rc}(4.14) = 1.4387E+008$$

$$u = s_u(4.1) = 1.4115955E-005$$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

Calculation of μ_{u2+}

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051

2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vsy2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20632353

Mu = MRc (4.14) = 1.4387E+008

u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_2 -

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

$$\mu = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.11295746$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.11295746$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20632353$$

$$\mu = MR_c (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 391586.536$

Calculation of Shear Strength at edge 1, $V_{r1} = 391586.536$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$$

$$V_{Col0} = 391586.536$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '

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

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.5320539E-012$

$V_u = 3.1643569E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 279249.888$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 391586.536$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_n I \cdot V_{Col0}$

$V_{Col0} = 391586.536$

$k_n = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.5320539E-012$

$V_u = 3.1643569E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 279249.888$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 250.00$

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

At local axis: 2

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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 5.1303366E-011$
Shear Force, $V_2 = 3886.204$
Shear Force, $V_3 = 2.9187433E-013$
Axial Force, $F = -4846.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{s,ten} = 829.3805$
-Compression: $A_{s,com} = 829.3805$
-Middle: $A_{s,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_bL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = * u = 0.025916$
 $u = y + p = 0.025916$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00531645$ ((4.29), Biskinis Phd)
 $M_y = 4.3651E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4846.244$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 8.9405911E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 248.9644$
 $d = 207.00$
 $y = 0.3273785$
 $A = 0.0201$
 $B = 0.01221219$
with $pt = 0.00801334$
 $pc = 0.00801334$
 $pv = 0.00388525$
 $N = 4846.244$
 $b = 500.00$

" = 0.20772947
y_comp = 2.5390916E-005
with fc = 20.00
Ec = 21019.039
y = 0.32586742
A = 0.01977524
B = 0.01202411
with Es = 200000.00

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

- Calculation of p -

From table 10-8: p = 0.02059956

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio $V_y E / V_{col} O E = 0.15700689$

d = 207.00

s = 0.00

t = $A_v / (b w * s) + 2 * t_f / b w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

bw = 500.00

The term $2 * t_f / b w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

NUD = 4846.244

Ag = 125000.00

f_{cE} = 20.00

f_{yE} = f_{yE} = 0.00

pl = $Area_Tot_Long_Rein / (b * d) = 0.01991193$

b = 500.00

d = 207.00

f_{cE} = 20.00

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

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

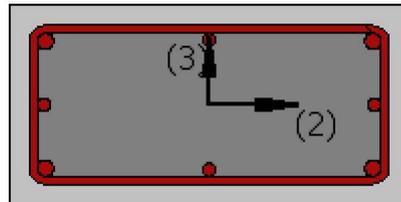
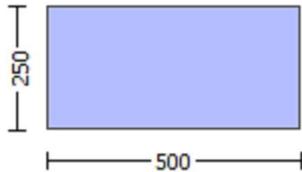
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 8.2514878E-010$

Shear Force, $V_a = -2.9187433E-013$
EDGE -B-
Bending Moment, $M_b = 5.1303366E-011$
Shear Force, $V_b = 2.9187433E-013$
BOTH EDGES
Axial Force, $F = -4846.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{sc,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 226273.861$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 226273.861$
 $V_{CoI} = 226273.861$
 $k_n = 1.00$
displacement_ductility_demand = 0.00

NOTE: In expression (10-3) ' $V_s = A_v \phi_f y d / s$ ' is replaced by ' $V_s + \phi V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 5.1303366E-011$
 $V_u = 2.9187433E-013$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4846.244$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 125663.706$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 100.00$
 V_s is multiplied by $\phi_{CoI} = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 500.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 2.6383042E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00531645$ ((4.29), Biskinis Phd)
 $M_y = 4.3651E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4846.244$
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 8.9405911\text{E-}006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/l_d)^{2/3}) = 248.9644$
 $d = 207.00$
 $y = 0.3273785$
 $A = 0.0201$
 $B = 0.01221219$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4846.244$
 $b = 500.00$
 $\gamma = 0.20772947$
 $y_{\text{comp}} = 2.5390916\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32586742$
 $A = 0.01977524$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

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

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

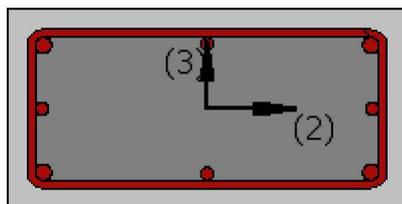
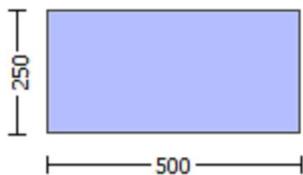
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (3)



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

At Shear local axis: 3
 (Bending local axis: 2)
 Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$

 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, $f_s = 1.25 \cdot f_{sm} = 555.55$

 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.00
 Element Length, $L = 3000.00$
 Secondary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 5.1679577E-032$
 EDGE -B-
 Shear Force, $V_b = -5.1679577E-032$
 BOTH EDGES
 Axial Force, $F = -4666.932$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 829.3805$
 -Compression: $A_{sl,com} = 829.3805$
 -Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.15700689$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 39559.707$
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 5.9340E+007$

$M_{u1+} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.9340E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 5.9340E+007$

$M_{u2+} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.9340E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 3.3157250E-005$

$M_u = 5.9340E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ω (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0050171$

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

From (5.4b), TBDY: $\phi_u = 0.0050171$

w_e (5.4c) = 0.00143849

a_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x} , \phi_{sh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $\phi_{sh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

From ((5.A5), TBDY), TBDY: $\phi_c = 0.002$

c = confinement factor = 1.00

$y_1 = 0.00129669$

$sh_1 = 0.0044814$

$ft_1 = 373.4467$

$fy_1 = 311.2056$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976

2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976

v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866

2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866

v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vsy2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.25403043

Mu = MRc (4.14) = 5.9340E+007

u = su (4.1) = 3.3157250E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_1 -

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

$$\mu = 3.3157250E-005$$

$$\mu_1 = 5.9340E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.12468976$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.12468976$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.06045564$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.16570866$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.16570866$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.08034359$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.25403043$$

$$Mu = MRc (4.14) = 5.9340E+007$$

$$u = su (4.1) = 3.3157250E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

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

$$u = 3.3157250E-005$$

$$Mu = 5.9340E+007$$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.00314159$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.00314159$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00628319$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 100.00$
 $fywe = 555.55$
 $fce = 20.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$

$y1 = 0.00129669$
 $sh1 = 0.0044814$
 $ft1 = 373.4467$
 $fy1 = 311.2056$
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/d = 0.30$

$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 311.2056$

with $Es1 = Es = 200000.00$

$y2 = 0.00129669$
 $sh2 = 0.0044814$
 $ft2 = 373.4467$
 $fy2 = 311.2056$
 $su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/lb,min = 0.30$

$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y2, sh2, ft2, fy2$, are also multiplied by $Min(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs2 = fs = 311.2056$

with $Es2 = Es = 200000.00$

$yv = 0.00129669$

$shv = 0.0044814$
 $ftv = 373.4467$
 $fyv = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.12468976$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.12468976$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.06045564$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.16570866$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.16570866$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08034359$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.25403043$
 $Mu = MRc (4.14) = 5.9340E+007$
 $u = su (4.1) = 3.3157250E-005$

 Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu2$ -

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

$u = 3.3157250E-005$
 $Mu = 5.9340E+007$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

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

psh,x (5.4d) = 0.00314159

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 500.00

psh,y (5.4d) = 0.00628319

Ash = Astir*ns = 78.53982

No stirrups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 555.55

fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00129669

sh1 = 0.0044814

ft1 = 373.4467

fy1 = 311.2056

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 311.2056$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.12468976$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.12468976$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.06045564$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 20.00$

$cc \text{ (5A.5, TBDY)} = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.16570866$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.16570866$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08034359$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su \text{ (4.9)} = 0.25403043$

$Mu = MRc \text{ (4.14)} = 5.9340E+007$

$u = su \text{ (4.1)} = 3.3157250E-005$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 251961.592$

Calculation of Shear Strength at edge 1, $V_{r1} = 251961.592$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

$f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$Mu = 3.4623283E-012$

$Vu = 5.1679577E-032$

$d = 0.8 \cdot h = 200.00$

$Nu = 4666.932$

$Ag = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 251961.592$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{Col0}$

$V_{Col0} = 251961.592$

$knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.4623283E-012$

$V_u = 5.1679577E-032$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 139624.944$

$A_v = 157079.633$

$f_y = 444.44$

$s = 100.00$

V_s is multiplied by $\text{Col} = 1.00$

$s/d = 0.50$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$

$b_w = 500.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

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, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou, \min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -3.1643569E-048$

EDGE -B-

Shear Force, $V_b = 3.1643569E-048$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 829.3805$

-Compression: $As_{c,com} = 829.3805$

-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.24493996$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 95915.192$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.4387E+008$

$M_{u1+} = 1.4387E+008$, 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

$M_{u1-} = 1.4387E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.4387E+008$

$M_{u2+} = 1.4387E+008$, 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

$M_{u2-} = 1.4387E+008$, 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 M_{u1+}

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

$\phi_u = 1.4115955E-005$

$M_u = 1.4387E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_{cc}) = 0.0050171$

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

From (5.4b), TBDY: $\phi_c = 0.0050171$

ϕ_{we} (5.4c) = 0.00143849

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{psh,x}$ (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{psh,y}$ (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00129669$
 $sh_1 = 0.0044814$
 $ft_1 = 373.4467$
 $fy_1 = 311.2056$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 311.2056$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00129669$
 $sh_2 = 0.0044814$
 $ft_2 = 373.4467$
 $fy_2 = 311.2056$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 311.2056$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00129669$
 $sh_v = 0.0044814$
 $ft_v = 373.4467$
 $fy_v = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.11295746$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.11295746$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.15907051$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.15907051$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.20632353$$

$$\mu_u = M_{Rc}(4.14) = 1.4387E+008$$

$$u = s_u(4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e(5.4c) = 0.00143849$$

$$a_{se}(5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 311.2056

with Es1 = Es = 200000.00

y2 = 0.00129669

sh2 = 0.0044814

ft2 = 373.4467

fy2 = 311.2056

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 311.2056

with Es2 = Es = 200000.00

yv = 0.00129669

shv = 0.0044814

ftv = 373.4467

fyv = 311.2056

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 311.2056

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746

2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746

v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051

2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051

v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vsy2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.20632353

Mu = MRc (4.14) = 1.4387E+008

u = su (4.1) = 1.4115955E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{2+}

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

$$\mu = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.0050171$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0050171$$

$$w_e \text{ (5.4c)} = 0.00143849$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00129669$$

$$sh_1 = 0.0044814$$

$$ft_1 = 373.4467$$

$$fy_1 = 311.2056$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 311.2056$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00129669$$

$$sh_2 = 0.0044814$$

$$ft_2 = 373.4467$$

$$fy_2 = 311.2056$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 311.2056$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00129669$$

$$shv = 0.0044814$$

$$ftv = 373.4467$$

$$fyv = 311.2056$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 311.2056$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.11295746$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.11295746$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.05476725$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.15907051$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.15907051$$

$$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.07712509$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.20632353$$

$$\mu_u = MR_c (4.14) = 1.4387E+008$$

$$u = su (4.1) = 1.4115955E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_u -

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

$$u = 1.4115955E-005$$

$$\mu_u = 1.4387E+008$$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0050171$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0050171$
 $we (5.4c) = 0.00143849$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.00314159$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.00314159$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00628319$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 100.00$
 $fywe = 555.55$
 $fce = 20.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$

$y1 = 0.00129669$
 $sh1 = 0.0044814$
 $ft1 = 373.4467$
 $fy1 = 311.2056$
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/d = 0.30$

$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 311.2056$

with $Es1 = Es = 200000.00$

$y2 = 0.00129669$
 $sh2 = 0.0044814$
 $ft2 = 373.4467$
 $fy2 = 311.2056$
 $su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/lb,min = 0.30$

$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y2, sh2, ft2, fy2$, are also multiplied by $Min(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs2 = fs = 311.2056$

with $Es2 = Es = 200000.00$

$yv = 0.00129669$

$shv = 0.0044814$
 $ftv = 373.4467$
 $fyv = 311.2056$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv , shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 311.2056$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.11295746$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.11295746$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05476725$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.15907051$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.15907051$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07712509$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.20632353$
 $Mu = MRc (4.14) = 1.4387E+008$
 $u = su (4.1) = 1.4115955E-005$

 Calculation of ratio lb/ld

 Inadequate Lap Length with $lb/ld = 0.30$

 Calculation of Shear Strength $Vr = Min(Vr1,Vr2) = 391586.536$

Calculation of Shear Strength at edge 1, $Vr1 = 391586.536$
 $Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$
 $VColO = 391586.536$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $fc' = 20.00$, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 2.5320539E-012$
 $Vu = 3.1643569E-048$
 $d = 0.8*h = 400.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $Vs = 279249.888$
 $Av = 157079.633$
 $fy = 444.44$

s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 391586.536
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 391586.536
knl = 1 (zero step-static loading)

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

= 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 = 2.5320539E-012
Vu = 3.1643569E-048
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 279249.888
Av = 157079.633
fy = 444.44
s = 100.00
Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

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

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

Constant Properties

Knowledge Factor, = 1.00
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
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lb/ld = 0.30
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 95988.968$
Shear Force, $V2 = 3886.204$
Shear Force, $V3 = 2.9187433E-013$
Axial Force, $F = -4846.244$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 829.3805$
-Compression: $As_{c,com} = 829.3805$
-Middle: $As_{c,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = \phi u = 0.03059615$
 $u = \gamma + \rho = 0.03059615$

- Calculation of γ -

$\gamma = (M \cdot L_s / 3) / E_{eff} = 0.00059615$ ((4.29), Biskinis Phd)
 $M_y = 9.7894E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.6421E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4846.244$
 $E_c \cdot I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \text{Min}(\gamma_{ten}, \gamma_{com})$
 $\gamma_{ten} = 3.8741252E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/l_d)^{2/3}) = 248.9644$
 $d = 457.00$
 $\gamma = 0.29689938$
 $A = 0.01820876$
 $B = 0.0100382$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4846.244$
 $b = 250.00$
 $\rho = 0.0940919$
 $\gamma_{comp} = 1.2695458E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $\gamma = 0.29520593$
 $A = 0.01791455$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of ρ -

From table 10-8: $\rho = 0.03$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_y E / V_{ColOE} = 0.24493996$

$$d = 457.00$$

$$s = 0.00$$

$$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$$

$A_v = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$b_w = 250.00$$

The term $2 * t_f / b_w * (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 * t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

$$N_{UD} = 4846.244$$

$$A_g = 125000.00$$

$$f_{cE} = 20.00$$

$$f_{ytE} = f_{ylE} = 0.00$$

$$\rho_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.01803838$$

$$b = 250.00$$

$$d = 457.00$$

$$f_{cE} = 20.00$$

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

At local axis: 3

Integration Section: (b)