

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

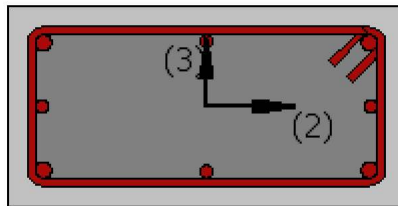
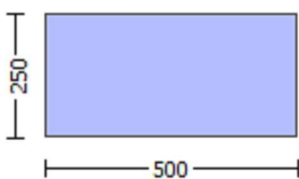
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

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, $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

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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).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

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Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.4257E+007$

Shear Force, $V_a = -4751.50$

EDGE -B-

Bending Moment, $M_b = -0.00088196$

Shear Force, $V_b = 4751.50$

BOTH EDGES

Axial Force, $F = -4665.031$

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: $As_{mid} = 402.1239$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 320061.918$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 320061.918$

$V_{CoI} = 320061.918$

$k_n = 1.00$

displacement_ductility_demand = 0.01896649

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)

$M/V_d = 4.00$

$M_u = 1.4257E+007$

$V_u = 4751.50$

$d = 0.8 \cdot h = 400.00$

$N_u = 4665.031$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 263893.783$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

V_s is multiplied by $CoI = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 250.00$

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 $\theta = 0.00019527$
 $y = (M_y * L_s / 3) / E_{eff} = 0.01029578$ ((4.29), Biskinis Phd))
 $M_y = 2.0703E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.571
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(\phi_{ten}, \phi_{com})$
 $\phi_{ten} = 7.9424731E-006$
with $f_y = 525.00$
 $d = 457.00$
 $y = 0.27680176$
 $A = 0.01811615$
 $B = 0.0099456$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $\phi = 0.0940919$
 $\phi_{comp} = 1.6615368E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

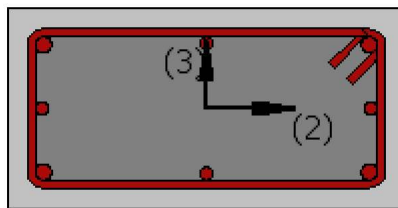
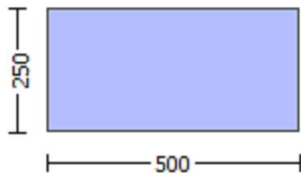
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\phi = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.29154496$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3221E+008$

$\mu_{u1+} = 1.3221E+008$, 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

$\mu_{u1-} = 1.3221E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3221E+008$

$\mu_{u2+} = 1.3221E+008$, 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

$\mu_{u2-} = 1.3221E+008$, 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 μ_{u1+}

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

$\mu_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
fywe = 656.25
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176

2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176

v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00
d = 177.00
d' = 13.00

```

fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

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Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu1-

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

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u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

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```

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

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

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```

s = 100.00
fywe = 656.25
fce = 30.00
From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25

```

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb,min)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```


Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{2+}

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

$\mu = 0.0002015$

$\mu_u = 1.3221 \times 10^{-8}$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

μ_{ue} (5.4c) = 0.00377606

α_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{u1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$,

For calculation of $\mu_{u1_nominal}$ 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

```

fy2 = 656.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    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/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 656.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.0002015
Mu = 1.3221E+008

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00595799$$

$$\phi_e (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00240019$$

$$\phi_c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \phi_{su1_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su1_nominal} = 0.08,$$

For calculation of $\phi_{su1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * \phi_{su2_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su2_nominal} = 0.08,$$

For calculation of $\phi_{su2_nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s2} = f_s = 656.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

```

ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = knl * V_{Co10}$

$V_{Co10} = 302309.152$

$knl = 1$ (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)

$f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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 <= 363854.192
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 302309.152
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 302309.152
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' = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.1816411E-012
Vu = 7.3920505E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 164933.614
Av = 157079.633
fy = 525.00
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 <= 363854.192
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, = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 25742.96
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
New material: Steel Strength, fs = 1.25*fsm = 656.25

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.04002
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.5261760E-048$
EDGE -B-
Shear Force, $V_b = -4.5261760E-048$
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, $V_e/V_r = 0.47299706$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$
with
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 3.3151E+008$
 $\mu_{1+} = 3.3151E+008$, 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
 $\mu_{1-} = 3.3151E+008$, 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
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 3.3151E+008$
 $\mu_{2+} = 3.3151E+008$, 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
 $\mu_{2-} = 3.3151E+008$, 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:

$$\mu = 8.2199924E-005$$

$$\mu_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \max(c_u, c_c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } c_u = 0.00595799$$

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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 = 656.25
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823

2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.14815151$
 $Mu = MR_c (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.2199924E-005$
 $Mu = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00595799$
 $we (5.4c) = 0.00377606$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$

 $psh,x (5.4d) = 0.00314159$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 500.00$

 $psh,y (5.4d) = 0.00628319$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 250.00$

 $s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5A5), TBDY), TBDY: $cc = 0.00240019$


```

c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied

```

--->

$$su(4.9) = 0.14815151$$

$$Mu = MRc(4.14) = 3.3151E+008$$

$$u = su(4.1) = 8.2199924E-005$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu_{2+}

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

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$we(5.4c) = 0.00377606$$

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

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

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

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 500.00$$

$$psh, y(5.4d) = 0.00628319$$

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

$$lo/lo, \min = lb/d = 1.00$$

$$su1 = 0.4 * esu1_{\text{nominal}}((5.5), TBDY) = 0.032$$

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

For calculation of $esu1_{\text{nominal}}$ $y1, sh1, ft1, fy1$, 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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
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/lb)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu2-

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

$$\phi_u = 8.2199924E-005$$

$$\mu_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_{co} (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we} (5.4c) = 0.00377606$$

$$\phi_{ase} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

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.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$
 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 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.15879823$
 $2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.15879823$
 $v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07699308$
 and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, \text{TBDY}) = 31.20058$
 $cc (5A.5, \text{TBDY}) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.22362502$
 $2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.22362502$
 $v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
 --->

$su (4.9) = 0.14815151$
 $Mu = MRc (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

 Calculation of ratio lb/ld

 Adequate Lap Length: $lb/ld \geq 1$

 Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 467242.766$

Calculation of Shear Strength at edge 1, $Vr1 = 467242.766$

$Vr1 = VCol ((10.3), \text{ASCE 41-17}) = knl \cdot VColO$
 $VColO = 467242.766$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $fc' = 30.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 \cdot h = 400.00$
 $Nu = 4666.932$

Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 329867.229
Av = 157079.633
fy = 525.00
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 <= 363854.192
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 467242.766
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 467242.766
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' = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.6217549E-012
Vu = 4.5261760E-048
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 329867.229
Av = 157079.633
fy = 525.00
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 <= 363854.192
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: rcrcs

Constant Properties

Knowledge Factor, $\phi = 0.85$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
Concrete Elasticity, $E_c = 25742.96$
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
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 1.1221826E-009$
Shear Force, $V_2 = -4751.50$
Shear Force, $V_3 = -4.1317099E-013$
Axial Force, $F = -4665.031$
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, $D_bL = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.01417633$
 $u = y + p = 0.01417633$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00923028$ ((4.29), Biskinis Phd))
 $M_y = 9.2818E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 5.0279E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 1.8256816E-005$
with $f_y = 525.00$
 $d = 207.00$
 $y = 0.30540138$
 $A = 0.01999778$
 $B = 0.01210997$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.031$
 $b = 500.00$
 $" = 0.20772947$
 $y_{comp} = 3.3230737E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.30494742$
 $A = 0.01980449$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.00494605$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_{yE}/V_{ColOE} = 0.29154496$

$d = 207.00$

$s = 0.00$

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

$A_v = 157.0796$, 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.

$NUD = 4665.031$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{ytE} = f_{ylE} = 0.00$

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

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

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

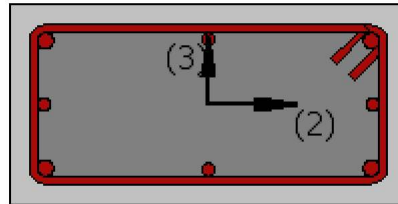
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

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, $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

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).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 1.1221826E-009$

Shear Force, $V_a = -4.1317099E-013$

EDGE -B-

Bending Moment, $M_b = 1.1815160E-010$

Shear Force, $V_b = 4.1317099E-013$

BOTH EDGES

Axial Force, $F = -4665.031$

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: $As_{l,ten} = 829.3805$

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

-Middle: $As_{l,mid} = 402.1239$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 244283.162$

V_n ((10.3), ASCE 41-17) = $kn1 \cdot V_{Col0} = 244283.162$

$V_{Col} = 244283.162$

$kn1 = 1.00$

$displacement_ductility_demand = 0.00$

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)

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

$M/Vd = 2.00$

$\mu_u = 1.1221826E-009$

$V_u = 4.1317099E-013$

$d = 0.8 \cdot h = 200.00$

$N_u = 4665.031$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 131946.891$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

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: $V_s + V_f \leq 297085.704$

$bw = 500.00$

$displacement_ductility_demand$ is calculated as γ / y

- Calculation of γ / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta = 5.8795680E-020$

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.00923028$ ((4.29), Biskinis Phd))

$M_y = 9.2818E+007$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$

$factor = 0.30$

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.031$

$E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \min(\gamma_{ten}, \gamma_{com})$

$\gamma_{ten} = 1.8256816E-005$

with $f_y = 525.00$

$d = 207.00$

$\gamma = 0.30540138$

$A = 0.01999778$

$B = 0.01210997$

with $pt = 0.00801334$

$pc = 0.00801334$

$pv = 0.00388525$

$N = 4665.031$

b = 500.00
" = 0.20772947
y_comp = 3.3230737E-005
with fc = 30.00
Ec = 25742.96
y = 0.30494742
A = 0.01980449
B = 0.01202411
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

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

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

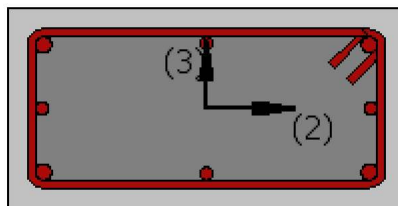
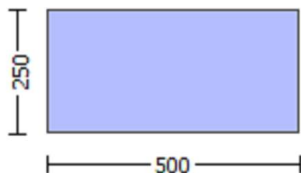
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (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, = 0.85

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

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, $V_e/V_r = 0.29154496$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.3221E+008$

$\mu_{1+} = 1.3221E+008$, 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

$\mu_{1-} = 1.3221E+008$, 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

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.3221E+008$

$\mu_{2+} = 1.3221E+008$, 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

$\mu_{2-} = 1.3221E+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi u: \phi u^* = \text{shear_factor} * \text{Max}(\phi u, \phi c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi u = 0.00595799$$

$$\phi w (5.4c) = 0.00377606$$

$$\phi a_s ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi c = 0.00240019$$

$$\phi c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 656.25$$

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

$$y_v = 0.0025$$

```

shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00

```

ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

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 = 656.25
fce = 30.00
From ((5.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25

```

with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015
-----

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

Calculation of Mu2+
-----
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 0.0002015
Mu = 1.3221E+008
-----

with full section properties:
b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
-----
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 = 656.25
fce = 30.00
From ((5A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfinedsd full section - Steel rupture

```

' does not satisfy Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.23279566

$M_u = M_{Rc}$ (4.14) = 1.3221E+008

$u = \mu_u$ (4.1) = 0.0002015

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u2} -

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

$\mu_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00595799$

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

From (5.4b), TBDY: $\mu_{cu} = 0.00595799$

μ_{we} (5.4c) = 0.00377606

μ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5A5), TBDY), TBDY: $\mu_{cc} = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$\mu_{su1} = 0.032$

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

$I_o/I_{ou,min} = I_b/I_d = 1.00$

$\mu_{su1} = 0.4 * \mu_{su1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $\mu_{su1_nominal} = 0.08$,

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
 From table 5A.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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.17529176$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.17529176$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08498995$

and confined core properties:

$b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.23295708$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.23295708$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11294889$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < vs, c$ - RHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.23279566$
 $Mu = MRc (4.14) = 1.3221E+008$
 $u = su (4.1) = 0.0002015$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 302309.152$

$k_{nl} = 1$ (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)

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.1816411\text{E-}012$

$V_u = 7.3920505\text{E-}032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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: $V_s + V_f \leq 363854.192$

$b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 302309.152$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 302309.152$

$k_{nl} = 1$ (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)

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.1816411\text{E-}012$

$V_u = 7.3920505\text{E-}032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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: $V_s + V_f \leq 363854.192$

$b_w = 500.00$

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: rcrcs

Constant Properties

Knowledge Factor, $\phi = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.5261760E-048$

EDGE -B-

Shear Force, $V_b = -4.5261760E-048$

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: $As_{l,com} = 829.3805$

-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.47299706$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.3151E+008$

$\mu_{u1+} = 3.3151E+008$, 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

$\mu_{u1-} = 3.3151E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.3151E+008$

$\mu_{u2+} = 3.3151E+008$, 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

$\mu_{u2-} = 3.3151E+008$, 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_{u1+}

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

$$\phi_u = 8.2199924E-005$$

$$\mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_{co} (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we} (5.4c) = 0.00377606$$

$$\phi_{ase} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \phi_{su1_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su1_nominal} = 0.08,$$

For calculation of $\phi_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = f_s/1.2$, 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.

$$\text{with } fs_1 = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * \phi_{su2_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su2_nominal} = 0.08,$$

For calculation of $\phi_{su2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, 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 $f_{s2} = f_s = 656.25$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.14815151$
 $Mu = MR_c (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_1 -

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

$u = 8.2199924E-005$
 $Mu = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

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

From (5.4b), TBDY: $c_u = 0.00595799$

w_e (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

$l_o/l_{ou,min} = l_b/l_d = 1.00$

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

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

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$fy_2 = 656.25$

$su_2 = 0.032$

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

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

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

with $fs_2 = fs = 656.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$su_v = 0.032$

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

$l_o/l_{ou,min} = l_b/l_d = 1.00$

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

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

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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 656.25$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.14815151

$Mu = MR_c$ (4.14) = 3.3151E+008

$u = su$ (4.1) = 8.2199924E-005

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_{2+}

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

$u = 8.2199924E-005$

$Mu = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

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

From (5.4b), TBDY: $cu = 0.00595799$

w_e (5.4c) = 0.00377606

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

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

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

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirups, $n_s = 2.00$

$bk = 500.00$

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From } ((5.5), \text{TDY}), \text{TDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

For calculation of $esu1_{\text{nominal}}$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TDY.

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

$$\text{with } fs1 = fs = 656.25$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

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

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su2 = 0.4 * esu2_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

For calculation of $esu2_{\text{nominal}}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TDY.

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

$$\text{with } fs2 = fs = 656.25$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 656.25$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.15879823$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.15879823$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TDY}) = 31.20058$$

$$cc (5A.5, \text{TDY}) = 0.00240019$$

$c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $\mu_u(4.9) = 0.14815151$
 $M_u = M_{Rc}(4.14) = 3.3151E+008$
 $u = \mu_u(4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u2} -

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

$u = 8.2199924E-005$
 $M_u = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $\alpha(5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.00595799$
 $\mu_{ue}(5.4c) = 0.00377606$
 $\mu_{ase}((5.4d), TBDY) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00314159$

$\mu_{sh,x}(5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\mu_{sh,y}(5.4d) = 0.00628319$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $\mu_{u1} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
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 $fs_1 = fs = 656.25$
with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 787.50$
 $fy_2 = 656.25$
 $su_2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
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.
with $fs_2 = fs = 656.25$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 656.25$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.15879823$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.15879823$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.07699308$
and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.22362502$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.22362502$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.10842425$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.14815151$
 $Mu = MRc (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$

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

$V_{Col0} = 467242.766$

$k_n l = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 363854.192$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 467242.766$

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

$V_{Col0} = 467242.766$

$k_n l = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 363854.192$

$b_w = 250.00$

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, $\phi = 0.85$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d > 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.4257E+007$

Shear Force, $V_2 = -4751.50$

Shear Force, $V_3 = -4.1317099E-013$

Axial Force, $F = -4665.031$

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: $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^* u = 0.01491271$

$u = y + p = 0.01491271$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01029578$ ((4.29), Biskinis Phd))

$M_y = 2.0703E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.571

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$

factor = 0.30

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.031$

$E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \text{Min}(\gamma_{\text{ten}}, \gamma_{\text{com}})$
 $\gamma_{\text{ten}} = 7.9424731\text{E-}006$
with $f_y = 525.00$
 $d = 457.00$
 $\gamma = 0.27680176$
 $A = 0.01811615$
 $B = 0.0099456$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $\gamma = 0.0940919$
 $\gamma_{\text{comp}} = 1.6615368\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $\gamma = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of ρ -

From table 10-8: $\rho = 0.00461692$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/d < 1$

shear control ratio $V_y E / V_{col} E = 0.47299706$

$d = 457.00$

$s = 0.00$

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

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

$b_w = 250.00$

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

where $f = 2 \cdot t_f / b_w$ 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.

$N_{UD} = 4665.031$

$A_g = 125000.00$

$f_{cE} = 30.00$

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

$\rho_l = \text{Area_Tot_Long_Rein} / (b \cdot d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 30.00$

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

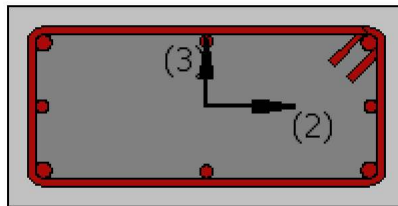
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

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).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.4257E+007$

Shear Force, $V_a = -4751.50$

EDGE -B-

Bending Moment, $M_b = -0.00088196$

Shear Force, $V_b = 4751.50$

BOTH EDGES

Axial Force, $F = -4665.031$

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, $D_{bL,ten} = 18.66667$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 376230.054$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col} = 376230.054$

$V_{Col} = 376230.054$

$k_n = 1.00$

$displacement_ductility_demand = 0.10328958$

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)

$M/Vd = 2.00$

$M_u = 0.00088196$

$V_u = 4751.50$

$d = 0.8 \cdot h = 400.00$

$N_u = 4665.031$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 263893.783$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

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: $V_s + V_f \leq 297085.704$

$b_w = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 0.00010632$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00102938$ ((4.29), Biskinis Phd))

$M_y = 2.0703E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.0112E+013$

$factor = 0.30$

$A_g = 125000.00$

$f'_c = 30.00$

N = 4665.031
Ec*Ig = 6.7039E+013

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 7.9424731\text{E-}006$
with $f_y = 525.00$
 $d = 457.00$
 $y = 0.27680176$
 $A = 0.01811615$
 $B = 0.0099456$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $" = 0.0940919$
 $y_{\text{comp}} = 1.6615368\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

Calculation No. 6

column C1, Floor 1

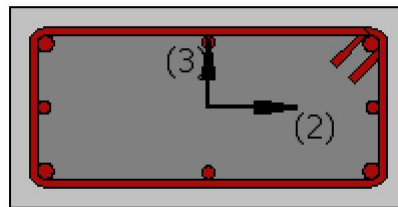
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_r)

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, $\phi = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_{lt} = 0.00$

-Compression: $As_{lc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.29154496$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3221\text{E}+008$
 $\mu_{u1+} = 1.3221\text{E}+008$, 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
 $\mu_{u1-} = 1.3221\text{E}+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3221\text{E}+008$
 $\mu_{u2+} = 1.3221\text{E}+008$, 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
 $\mu_{u2-} = 1.3221\text{E}+008$, 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 μ_{u1+}

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

$\mu_u = 0.0002015$
 $\mu_u = 1.3221\text{E}+008$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00150304$
 $N = 4666.932$
 $f_c = 30.00$
 $\alpha (5A.5, \text{TBDY}) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.00595799$
 $\mu_{we} (5.4c) = 0.00377606$
 $\mu_{ase} ((5.4d), \text{TBDY}) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00314159$

 $\mu_{psh,x} (5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 500.00$

$\mu_{psh,y} (5.4d) = 0.00628319$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A5), TBDY), TBDY: $\mu_{cc} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $f_{t1} = 787.50$
 $f_{y1} = 656.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/d = 1.00$

```

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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

$$\mu = 0.0002015$$

$$Mu = 1.3221E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

```

lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

u = 0.0002015
Mu = 1.3221E+008

with full section properties:

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304

$N = 4666.932$
 $f_c = 30.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.00595799$
 $w_e (5.4c) = 0.00377606$
 $\alpha_{se} ((5.4d), TBDY) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_i^2 = 459400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

$p_{sh,x} (5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 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, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5A5), TBDY), TBDY: $\alpha_c = 0.00240019$
 $\alpha_c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * \alpha_{su1_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\alpha_{su1_nominal} = 0.08$,
 For calculation of $\alpha_{su1_nominal}$ 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 $fs_1 = fs = 656.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 787.50$
 $fy_2 = 656.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * \alpha_{su2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\alpha_{su2_nominal} = 0.08$,
 For calculation of $\alpha_{su2_nominal}$ 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.
 with $fs_2 = fs = 656.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $su_v = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with


```

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
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 = 656.25
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176

2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176

v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00

$d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->

$su (4.9) = 0.23279566$
 $Mu = MR_c (4.14) = 1.3221E+008$
 $u = su (4.1) = 0.0002015$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 302309.152$
 $k_{nl} = 1$ (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)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 6.1816411E-012$
 $Vu = 7.3920505E-032$
 $d = 0.8 * h = 200.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 164933.614$
 $Av = 157079.633$
 $f_y = 525.00$
 $s = 100.00$
 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: $V_s + V_f \leq 363854.192$
 $bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 302309.152$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 302309.152$
 $k_{nl} = 1$ (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)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 6.1816411E-012$
 $Vu = 7.3920505E-032$

d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 164933.614
Av = 157079.633
fy = 525.00
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 <= 363854.192
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, $\phi = 0.85$
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
Concrete Elasticity, $E_c = 25742.96$
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
New material: Steel Strength, $f_s = 1.25*f_{sm} = 656.25$

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.04002
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.5261760E-048$
EDGE -B-
Shear Force, $V_b = -4.5261760E-048$
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: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.47299706$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3151E+008$

$M_{u1+} = 3.3151E+008$, 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

$M_{u1-} = 3.3151E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3151E+008$

$M_{u2+} = 3.3151E+008$, 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

$M_{u2-} = 3.3151E+008$, 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 M_{u1+}

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

$\phi_u = 8.2199924E-005$

$M_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

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

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

$\phi_{we} \text{ (5.4c)} = 0.00377606$

$\phi_{ase} \text{ ((5.4d), TBDY)} = 0.05494666$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\phi_{cc} = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$f_{t1} = 787.50$

$f_{y1} = 656.25$

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_1 -

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

$\mu = 8.2199924E-005$

$\mu_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

μ_{ue} (5.4c) = 0.00377606

α_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{u1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$,

For calculation of $\mu_{u1_nominal}$ 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

```

fy2 = 656.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    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/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 656.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

u = 8.2199924E-005

Mu = 3.3151E+008

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00595799$$

$$\phi_e (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00240019$$

$$\phi_c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \phi_{su1_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su1_nominal} = 0.08,$$

For calculation of $\phi_{su1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * \phi_{su2_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su2_nominal} = 0.08,$$

For calculation of $\phi_{su2_nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s2} = f_s = 656.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

```

ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
    2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 8.2199924E-005

Mu = 3.3151E+008

with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

fc = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00595799

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

From (5.4b), TBDY: cu = 0.00595799

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

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 = 656.25
fce = 30.00

From ((5A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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/lb)^ 2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

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

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).

$$= 1 \text{ (normal-weight concrete)}$$

$$f'_c = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 3.6217549E-012$$

$$V_u = 4.5261760E-048$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 329867.229$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

$$V_s \text{ is multiplied by } C_{ol} = 1.00$$

$$s/d = 0.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 363854.192$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 467242.766$

$$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

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

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)
 $f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 3.6217549E-012$
 $\nu_u = 4.5261760E-048$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 363854.192$
 $b_w = 250.00$

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, $\phi = 0.85$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 1.1815160E-010$
 Shear Force, $V_2 = 4751.50$
 Shear Force, $V_3 = 4.1317099E-013$
 Axial Force, $F = -4665.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 2060.885$
 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, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0 \cdot u = 0.01417633$
 $u = y + p = 0.01417633$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00923028$ ((4.29), Biskinis Phd))
 $M_y = 9.2818E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 1.8256816E-005$
with $f_y = 525.00$
 $d = 207.00$
 $y = 0.30540138$
 $A = 0.01999778$
 $B = 0.01210997$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.031$
 $b = 500.00$
 $" = 0.20772947$
 $y_{comp} = 3.3230737E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.30494742$
 $A = 0.01980449$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.00494605$

with:

- Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$

shear control ratio $V_y E / V_{col} E = 0.29154496$

$d = 207.00$

$s = 0.00$

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

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

$b_w = 500.00$

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

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

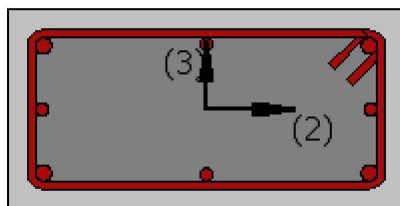
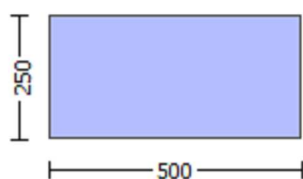
All these variables have already been given in Shear control ratio calculation.

NUD = 4665.031
Ag = 125000.00
fcE = 30.00
fyE = fyLE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01991193
b = 500.00
d = 207.00
fcE = 30.00

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: Immediate Occupancy (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, $\gamma = 0.85$
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$
 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).
 New material: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material: Steel Strength, $f_s = f_{sm} = 525.00$
 #####
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 1.1221826E-009$
 Shear Force, $V_a = -4.1317099E-013$
 EDGE -B-
 Bending Moment, $M_b = 1.1815160E-010$
 Shear Force, $V_b = 4.1317099E-013$
 BOTH EDGES
 Axial Force, $F = -4665.031$
 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: $As_{mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 244283.162$
 V_n ((10.3), ASCE 41-17) = $knI \cdot V_{CoI} = 244283.162$
 $V_{CoI} = 244283.162$
 $knI = 1.00$
 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)
 $f'_c = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 1.1815160E-010$
 $V_u = 4.1317099E-013$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4665.031$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 131946.891$
 $A_v = 157079.633$
 $f_y = 420.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 1.00$
 $s/d = 0.50$

Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

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 $\theta_r = 2.6253864E-020$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00923028$ ((4.29), Biskinis Phd))
 $M_y = 9.2818E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 5.0279E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 1.8256816E-005$
with $f_y = 525.00$
 $d = 207.00$
 $y = 0.30540138$
 $A = 0.01999778$
 $B = 0.01210997$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.031$
 $b = 500.00$
 $\phi_{y_com} = 3.3230737E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.30494742$
 $A = 0.01980449$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

Calculation No. 8

column C1, Floor 1

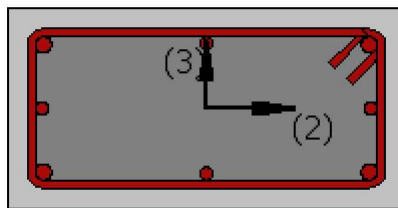
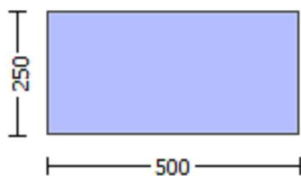
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.29154496$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3221E+008$

$\mu_{u1+} = 1.3221E+008$, 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

$\mu_{u1-} = 1.3221E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3221E+008$

$\mu_{u2+} = 1.3221E+008$, 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

$\mu_{u2-} = 1.3221E+008$, 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 μ_{u1+}

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

$\mu_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
 fywe = 656.25
 fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
 c = confinement factor = 1.04002

y1 = 0.0025
 sh1 = 0.008
 ft1 = 787.50
 fy1 = 656.25
 su1 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
 sh2 = 0.008
 ft2 = 787.50
 fy2 = 656.25
 su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
 shv = 0.008
 ftv = 787.50
 fyv = 656.25
 suv = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176

2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176

v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00
 d = 177.00
 d' = 13.00

```

fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

```

```

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 = 656.25
fce = 30.00
From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25

```

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb,min)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{2+}

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

$\mu = 0.0002015$

$\mu_u = 1.3221 \times 10^{-8}$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

μ_{ue} (5.4c) = 0.00377606

α_{se} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{u1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$

For calculation of $\mu_{u1_nominal}$ 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

```

fy2 = 656.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    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/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 656.25
    with Es2 = Es = 200000.00
    yv = 0.0025
    shv = 0.008
    ftv = 787.50
    fyv = 656.25
    suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.0002015
Mu = 1.3221E+008

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi u^* = \text{shear_factor} * \text{Max}(\phi u, \phi c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi u = 0.00595799$$

$$\phi u_e (5.4c) = 0.00377606$$

$$\phi a_s ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 656.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

```

ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Co1} ((10.3), \text{ASCE } 41-17) = knl * V_{Co10}$

$V_{Co10} = 302309.152$

$knl = 1$ (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)

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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 <= 363854.192
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 302309.152
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 302309.152
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' = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.1816411E-012
Vu = 7.3920505E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 164933.614
Av = 157079.633
fy = 525.00
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 <= 363854.192
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, $\phi = 0.85$
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
Concrete Elasticity, $E_c = 25742.96$
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
New material: Steel Strength, $f_s = 1.25*f_{sm} = 656.25$

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.04002
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.5261760E-048$
EDGE -B-
Shear Force, $V_b = -4.5261760E-048$
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: $As_{l,com} = 829.3805$
-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.47299706$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.3151E+008$
 $\mu_{u1+} = 3.3151E+008$, 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
 $\mu_{u1-} = 3.3151E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.3151E+008$
 $\mu_{u2+} = 3.3151E+008$, 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
 $\mu_{u2-} = 3.3151E+008$, 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_{u1+}

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

$$\mu_u = 8.2199924E-005$$

$$\mu_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \max(c_u, c_c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } c_u = 0.00595799$$

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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 = 656.25
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823

2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $s_u (4.9) = 0.14815151$
 $M_u = M_{Rc} (4.14) = 3.3151E+008$
 $u = s_u (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.2199924E-005$
 $\mu_u = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $cc (5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.00595799$
 $w_e (5.4c) = 0.00377606$
 $a_{se} ((5.4d), TBDY) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

$p_{sh,x} (5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 500.00$

$p_{sh,y} (5.4d) = 0.00628319$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirups, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5A5), TBDY), TBDY: $cc = 0.00240019$

```

c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied

```

--->

$$su(4.9) = 0.14815151$$

$$Mu = MRc(4.14) = 3.3151E+008$$

$$u = su(4.1) = 8.2199924E-005$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu_{2+}

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

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$we(5.4c) = 0.00377606$$

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

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

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

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 500.00$$

$$psh, y(5.4d) = 0.00628319$$

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

$$lo/lo, \min = lb/d = 1.00$$

$$su1 = 0.4 * esu1_{\text{nominal}}((5.5), TBDY) = 0.032$$

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

For calculation of $esu1_{\text{nominal}}$ $y1$, $sh1$, $ft1$, $fy1$, 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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/ld)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

$$\phi_u = 8.2199924E-005$$

$$\mu_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_{co} (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.00595799$$

$$\phi_{we} (5.4c) = 0.00377606$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu1_nominal ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu1_nominal = 0.08,$$

For calculation of $esu1_nominal$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = f_{s1}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu2_nominal ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu2_nominal = 0.08,$$

For calculation of $esu2_nominal$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = f_{s2}/1.2$, from table 5.1, TB DY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$
 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 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.15879823$
 $2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.15879823$
 $v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07699308$
 and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, \text{TBDY}) = 31.20058$
 $cc (5A.5, \text{TBDY}) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.22362502$
 $2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.22362502$
 $v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
 --->

$su (4.9) = 0.14815151$
 $Mu = MRc (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

 Calculation of ratio lb/ld

 Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 467242.766$

Calculation of Shear Strength at edge 1, $Vr1 = 467242.766$
 $Vr1 = VCol ((10.3), \text{ASCE 41-17}) = knl \cdot VColO$
 $VColO = 467242.766$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $fc' = 30.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 \cdot h = 400.00$
 $Nu = 4666.932$

Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 329867.229
Av = 157079.633
fy = 525.00
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 <= 363854.192
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 467242.766
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 467242.766
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' = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.6217549E-012
Vu = 4.5261760E-048
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 329867.229
Av = 157079.633
fy = 525.00
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 <= 363854.192
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: rcrcs

Constant Properties

Knowledge Factor, $\phi = 0.85$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
Concrete Elasticity, $E_c = 25742.96$
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
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -0.00088196$
Shear Force, $V_2 = 4751.50$
Shear Force, $V_3 = 4.1317099E-013$
Axial Force, $F = -4665.031$
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: $As_{mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.0056463$
 $u = y + p = 0.0056463$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00102938$ ((4.29), Biskinis Phd))
 $M_y = 2.0703E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 7.9424731E-006$
with $f_y = 525.00$
 $d = 457.00$
 $y = 0.27680176$
 $A = 0.01811615$
 $B = 0.0099456$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $" = 0.0940919$
 $y_{comp} = 1.6615368E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.00461692$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_{yE}/V_{ColOE} = 0.47299706$

$d = 457.00$

$s = 0.00$

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

$A_v = 157.0796$, 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.

$N_{UD} = 4665.031$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{ytE} = f_{ylE} = 0.00$

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

$b = 250.00$

$d = 457.00$

$f_{cE} = 30.00$

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

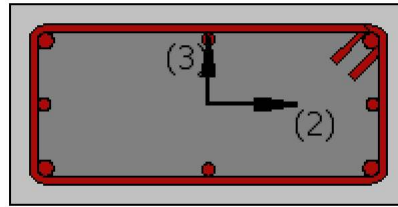
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

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).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -9.0404E+006$

Shear Force, $V_a = -3012.903$

EDGE -B-

Bending Moment, $M_b = -0.00055925$

Shear Force, $V_b = 3012.903$

BOTH EDGES

Axial Force, $F = -4665.726$

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: $As_{l,ten} = 829.3805$

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

-Middle: $As_{l,mid} = 402.1239$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 320061.987$

$V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 320061.987$

$V_{Col} = 320061.987$

$knl = 1.00$

$displacement_ductility_demand = 0.01202655$

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)

$M/Vd = 4.00$

$\mu_u = 9.0404E+006$

$V_u = 3012.903$

$d = 0.8 \cdot h = 400.00$

$N_u = 4665.726$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 263893.783$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

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: $V_s + V_f \leq 297085.704$

$bw = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 0.00012382$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.01029579 ((4.29), Biskinis Phd))$

$M_y = 2.0703E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.571

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.0112E+013$

$factor = 0.30$

$A_g = 125000.00$

$f'_c = 30.00$

$N = 4665.726$

$E_c \cdot I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \min(\phi_{ten}, \phi_{com})$

$\phi_{ten} = 7.9424748E-006$

with $f_y = 525.00$

$d = 457.00$

$y = 0.27680192$

$A = 0.01811617$

$B = 0.00994561$

with $pt = 0.00725935$

$pc = 0.00725935$

$pv = 0.00351968$

$N = 4665.726$

b = 250.00
" = 0.0940919
y_comp = 1.6615364E-005
with fc = 30.00
Ec = 25742.96
y = 0.27625441
A = 0.01794104
B = 0.00986782
with Es = 200000.00

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

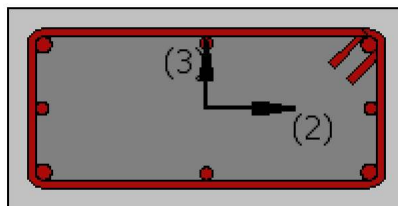
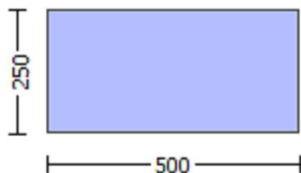
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

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, $V_e/V_r = 0.29154496$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.3221E+008$

$\mu_{1+} = 1.3221E+008$, 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

$\mu_{1-} = 1.3221E+008$, 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

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.3221E+008$

$\mu_{2+} = 1.3221E+008$, 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

$\mu_{2-} = 1.3221E+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_c: \phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } \phi_c = 0.00595799$$

$$\phi_w (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $fsy_1 = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

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

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

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered characteristic value $fsy_2 = f_{s2}/1.2$, 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.

$$\text{with } f_{s2} = f_s = 656.25$$

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

$$y_v = 0.0025$$

```

shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00

```

ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

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 = 656.25
fce = 30.00
From ((5.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25

```

with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015
-----

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

Calculation of Mu2+
-----
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 0.0002015
Mu = 1.3221E+008
-----

with full section properties:
b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
-----
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 = 656.25
fce = 30.00
From ((5A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfinedsd full section - Steel rupture

```

' does not satisfy Eq. (4.3)

--->

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

--->

$\mu_u(4.9) = 0.23279566$

$\mu_u = M_{Rc}(4.14) = 1.3221E+008$

$u = \mu_u(4.1) = 0.0002015$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u2} -

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

$u = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha(5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

$\mu_{ue}(5.4c) = 0.00377606$

$\mu_{ase}((5.4d), TBDY) = 0.05494666$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5A5), TBDY), TBDY: $\mu_c = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$\mu_{u1} = 0.032$

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

$I_o/I_{ou,min} = I_b/I_d = 1.00$

$\mu_{u1} = 0.4 * \mu_{u1_nominal}((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$,

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
 From table 5A.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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.17529176$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.17529176$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08498995$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.23295708$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.23295708$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11294889$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.23279566$
 $Mu = MRc (4.14) = 1.3221E+008$
 $u = su (4.1) = 0.0002015$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 302309.152$

$k_{nl} = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.1816411\text{E-}012$

$V_u = 7.3920505\text{E-}032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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: $V_s + V_f \leq 363854.192$

$b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 302309.152$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 302309.152$

$k_{nl} = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.1816411\text{E-}012$

$V_u = 7.3920505\text{E-}032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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: $V_s + V_f \leq 363854.192$

$b_w = 500.00$

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: rcrcs

Constant Properties

Knowledge Factor, $\phi = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.5261760E-048$

EDGE -B-

Shear Force, $V_b = -4.5261760E-048$

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: $As_{l,com} = 829.3805$

-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.47299706$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.3151E+008$

$\mu_{u1+} = 3.3151E+008$, 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

$\mu_{u1-} = 3.3151E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.3151E+008$

$\mu_{u2+} = 3.3151E+008$, 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

$\mu_{u2-} = 3.3151E+008$, 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_{u1+}

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

$$\phi_u = 8.2199924E-005$$

$$\mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we} (5.4c) = 0.00377606$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5A.5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu1_{nominal}$ and y_1, sh_1, 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.

$$\text{with } fs_1 = fs = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_b,min = 1.00$$

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

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

For calculation of $esu2_{nominal}$ and y_2, sh_2, ft_2, fy_2 , 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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{s2} = f_s = 656.25$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $f_{yv} = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, f_{yv} , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.14815151$
 $Mu = MR_c (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_1 -

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

$u = 8.2199924E-005$
 $Mu = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

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

From (5.4b), TBDY: $c_u = 0.00595799$

w_e (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00240019$

$c =$ confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

$l_o/l_{ou,min} = l_b/l_d = 1.00$

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

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

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$fy_2 = 656.25$

$su_2 = 0.032$

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

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

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

with $fs_2 = fs = 656.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$suv = 0.032$

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

$l_o/l_{ou,min} = l_b/l_d = 1.00$

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

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

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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 656.25$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.14815151

$Mu = MR_c$ (4.14) = 3.3151E+008

$u = su$ (4.1) = 8.2199924E-005

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_{2+}

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

$u = 8.2199924E-005$

$Mu = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

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

From (5.4b), TBDY: $cu = 0.00595799$

w_e (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00314159$

psh_x (5.4d) = 0.00314159

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirups, $n_s = 2.00$

$bk = 500.00$

psh_y (5.4d) = 0.00628319

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From } ((5.5), \text{TDY}), \text{TDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

For calculation of $esu1_{\text{nominal}}$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TDY.

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

$$\text{with } fs1 = fs = 656.25$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

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

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su2 = 0.4 * esu2_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

For calculation of $esu2_{\text{nominal}}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TDY.

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

$$\text{with } fs2 = fs = 656.25$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 656.25$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.15879823$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.15879823$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TDY}) = 31.20058$$

$$cc (5A.5, \text{TDY}) = 0.00240019$$

$c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $\mu_u(4.9) = 0.14815151$
 $M_u = M_{Rc}(4.14) = 3.3151E+008$
 $u = \mu_u(4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u2} -

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

$u = 8.2199924E-005$
 $\mu_u = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $\mu_{co}(5A.5, \text{TBDY}) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.00595799$
 $\mu_{we}(5.4c) = 0.00377606$
 $\mu_{ase}((5.4d), \text{TBDY}) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00314159$

$\mu_{psh,x}(5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\mu_{psh,y}(5.4d) = 0.00628319$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A5), TBDY), TBDY: $\mu_{cc} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $\mu_{su1} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 656.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 787.50$
 $fy_2 = 656.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 656.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.15879823$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.15879823$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.22362502$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.22362502$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.14815151$
 $Mu = MRc (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

 Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l * V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 363854.192$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 467242.766$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l * V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 363854.192$

$b_w = 250.00$

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: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\phi = 0.85$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d > 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 7.1383242E-010$

Shear Force, $V_2 = -3012.903$

Shear Force, $V_3 = -2.6198972E-013$

Axial Force, $F = -4665.726$

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: $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^* u = 0.05034923$

$u = y + p = 0.05034923$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00923029$ ((4.29), Biskinis Phd))

$M_y = 9.2818E+007$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 5.0279E+012$

factor = 0.30

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.726$

$E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.8256820\text{E-}005$
with $f_y = 525.00$
 $d = 207.00$
 $\rho_y = 0.30540153$
 $A = 0.0199978$
 $B = 0.01210998$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.726$
 $b = 500.00$
 $\rho_y = 0.20772947$
 $y_{\text{comp}} = 3.3230728\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $\rho_y = 0.3049475$
 $A = 0.01980448$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of ρ_p -

From table 10-8: $\rho_p = 0.04111895$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/d < 1$

shear control ratio $V_y E / V_{col} E = 0.29154496$

$d = 207.00$

$s = 0.00$

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

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

$b_w = 500.00$

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

where $f = 2 \cdot t_f / b_w$ 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.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

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

$\rho_l = \text{Area_Tot_Long_Rein} / (b \cdot d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

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

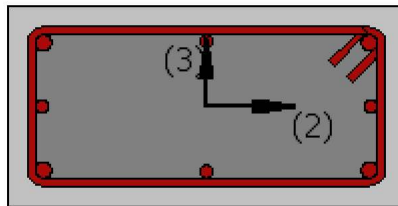
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

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).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 7.1383242\text{E-}010$

Shear Force, $V_a = -2.6198972\text{E-}013$

EDGE -B-

Bending Moment, $M_b = 7.2657463\text{E-}011$

Shear Force, $V_b = 2.6198972\text{E-}013$

BOTH EDGES

Axial Force, $F = -4665.726$

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: $As_{mid} = 402.1239$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 244283.30$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col} = 244283.30$

$V_{Col} = 244283.30$

$k_n = 1.00$

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)

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

$M/Vd = 2.00$

$M_u = 7.1383242\text{E-}010$

$V_u = 2.6198972\text{E-}013$

$d = 0.8 \cdot h = 200.00$

$N_u = 4665.726$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 131946.891$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

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: $V_s + V_f \leq 297085.704$

$bw = 500.00$

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 $\phi = 3.7282056\text{E-}020$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00923029$ ((4.29), Biskinis Phd))

$M_y = 9.2818\text{E+}007$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 5.0279\text{E+}012$

factor = 0.30

$A_g = 125000.00$

$f'_c = 30.00$

N = 4665.726
Ec*Ig = 1.6760E+013

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

y = Min(y_{ten} , y_{com})
 $y_{ten} = 1.8256820E-005$
with $f_y = 525.00$
d = 207.00
y = 0.30540153
A = 0.0199978
B = 0.01210998
with $p_t = 0.00801334$
pc = 0.00801334
pv = 0.00388525
N = 4665.726
b = 500.00
" = 0.20772947
 $y_{comp} = 3.3230728E-005$
with $f_c = 30.00$
Ec = 25742.96
y = 0.3049475
A = 0.01980448
B = 0.01202411
with Es = 200000.00

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

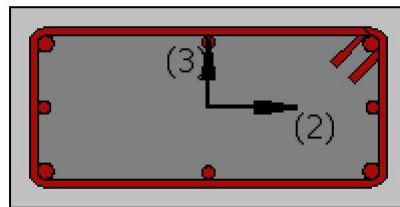
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $\phi = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_{lt} = 0.00$

-Compression: $As_{lc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.29154496$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3221\text{E}+008$
 $\mu_{u1+} = 1.3221\text{E}+008$, 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
 $\mu_{u1-} = 1.3221\text{E}+008$, 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
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3221\text{E}+008$
 $\mu_{u2+} = 1.3221\text{E}+008$, 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
 $\mu_{u2-} = 1.3221\text{E}+008$, 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 μ_{u1+}

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

$\mu_u = 0.0002015$
 $\mu_u = 1.3221\text{E}+008$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00150304$
 $N = 4666.932$
 $f_c = 30.00$
 $\alpha (5A.5, \text{TBDY}) = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.00595799$
 $\mu_c (5.4c) = 0.00377606$
 $\alpha_s ((5.4d), \text{TBDY}) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_i^2 = 459400.00$
 $\rho_{sh,min} = \text{Min}(\rho_{sh,x}, \rho_{sh,y}) = 0.00314159$

$\rho_{sh,x} (5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\rho_{sh,y} (5.4d) = 0.00628319$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $f_{t1} = 787.50$
 $f_{y1} = 656.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/d = 1.00$

```

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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

$$\mu = 0.0002015$$

$$Mu = 1.3221E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = f_{s1}/1.2$, 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.

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

```

lo/lou,min = lb/lb,min = 1.00
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/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

u = 0.0002015
Mu = 1.3221E+008

with full section properties:

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304

$N = 4666.932$
 $f_c = 30.00$
 $\phi_c (5A.5, TBDY) = 0.002$
 Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_c = 0.00595799$
 $\phi_w (5.4c) = 0.00377606$
 $\phi_{ase} ((5.4d), TBDY) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_i^2 = 459400.00$
 $\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00314159$

$\phi_{sh,x} (5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 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, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5A5), TBDY), TBDY: $\phi_c = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * \phi_{su1_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\phi_{su1_nominal} = 0.08$,
 For calculation of $\phi_{su1_nominal}$ 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 $fs_1 = fs = 656.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 787.50$
 $fy_2 = 656.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * \phi_{su2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\phi_{su2_nominal} = 0.08$,
 For calculation of $\phi_{su2_nominal}$ 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.
 with $fs_2 = fs = 656.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $su_v = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
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 = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
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 = 656.25
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176

2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176

v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00

$d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->

$su (4.9) = 0.23279566$
 $Mu = MR_c (4.14) = 1.3221E+008$
 $u = su (4.1) = 0.0002015$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 302309.152$
 $k_{nl} = 1$ (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)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 6.1816411E-012$
 $Vu = 7.3920505E-032$
 $d = 0.8 * h = 200.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 164933.614$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$
 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: $V_s + V_f \leq 363854.192$
 $bw = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 302309.152$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 302309.152$
 $k_{nl} = 1$ (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)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 6.1816411E-012$
 $Vu = 7.3920505E-032$

d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 164933.614
Av = 157079.633
fy = 525.00
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 <= 363854.192
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, $\phi = 0.85$
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
Concrete Elasticity, $E_c = 25742.96$
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
New material: Steel Strength, $f_s = 1.25*f_{sm} = 656.25$

Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.04002
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.5261760E-048$
EDGE -B-
Shear Force, $V_b = -4.5261760E-048$
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: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.47299706$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3151E+008$

$M_{u1+} = 3.3151E+008$, 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

$M_{u1-} = 3.3151E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3151E+008$

$M_{u2+} = 3.3151E+008$, 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

$M_{u2-} = 3.3151E+008$, 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 M_{u1+}

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

$\phi_u = 8.2199924E-005$

$M_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

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

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

$\phi_{we} \text{ (5.4c)} = 0.00377606$

$\phi_{ase} \text{ ((5.4d), TBDY)} = 0.05494666$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\phi_{cc} = 0.00240019$

$\phi_c = \text{confinement factor} = 1.04002$

$\phi_{y1} = 0.0025$

$\phi_{sh1} = 0.008$

$f_{t1} = 787.50$

$f_{y1} = 656.25$

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb,min)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_1 -

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

$\mu = 8.2199924E-005$

$\mu_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

μ_{ue} (5.4c) = 0.00377606

μ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{u1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$,

For calculation of $\mu_{u1_nominal}$ 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

```

fy2 = 656.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    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/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 656.25
    with Es2 = Es = 200000.00
    yv = 0.0025
    shv = 0.008
    ftv = 787.50
    fyv = 656.25
    suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
    2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

u = 8.2199924E-005

Mu = 3.3151E+008

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi u^* = \text{shear_factor} * \text{Max}(\phi u, \phi c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi u = 0.00595799$$

$$\phi w (5.4c) = 0.00377606$$

$$\phi a_s ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi c = 0.00240019$$

$$\phi c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered

characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered

characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 656.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

```

ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
    2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
    v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
    b = 190.00
    d = 427.00
    d' = 13.00
    fcc (5A.2, TBDY) = 31.20058
    cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 8.2199924E-005

Mu = 3.3151E+008

with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

fc = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00595799

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

From (5.4b), TBDY: cu = 0.00595799

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

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 = 656.25
fce = 30.00

From ((5A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

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

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).

$$= 1 \text{ (normal-weight concrete)}$$

$$f'_c = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 3.6217549E-012$$

$$V_u = 4.5261760E-048$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 329867.229$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

$$V_s \text{ is multiplied by } Col = 1.00$$

$$s/d = 0.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 363854.192$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 467242.766$

$$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

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

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)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 3.6217549E-012$
 $\nu_u = 4.5261760E-048$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 363854.192$
 $b_w = 250.00$

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, $\phi = 0.85$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -9.0404E+006$
 Shear Force, $V_2 = -3012.903$
 Shear Force, $V_3 = -2.6198972E-013$
 Axial Force, $F = -4665.726$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 2060.885$
 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, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^* u = 0.06032858$
 $u = y + p = 0.06032858$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01029579$ ((4.29), Biskinis Phd))
 $M_y = 2.0703E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.571
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.726$
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 7.9424748E-006$
with $f_y = 525.00$
 $d = 457.00$
 $y = 0.27680192$
 $A = 0.01811617$
 $B = 0.00994561$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.726$
 $b = 250.00$
 $" = 0.0940919$
 $y_{comp} = 1.6615364E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625441$
 $A = 0.01794104$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.05003279$

with:

- Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$

shear control ratio $V_y E / V_{col} E = 0.47299706$

$d = 457.00$

$s = 0.00$

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

$A_v = 157.0796$, 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

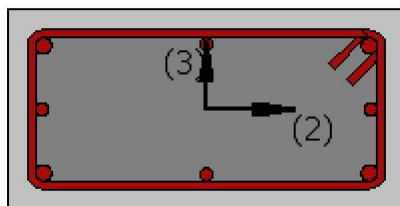
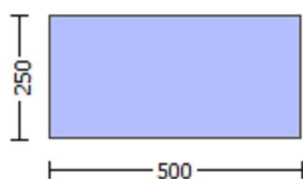
All these variables have already been given in Shear control ratio calculation.

NUD = 4665.726
Ag = 125000.00
fcE = 30.00
fytE = fyle = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.01803838
b = 250.00
d = 457.00
fcE = 30.00

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: Collapse Prevention (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity VRd
Edge: End
Local Axis: (2)



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

Constant Properties

Knowledge Factor, = 0.85
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 420.00

Concrete Elasticity, $E_c = 25742.96$
 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).
 New material: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material: Steel Strength, $f_s = f_{sm} = 525.00$
 #####
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -9.0404E+006$
 Shear Force, $V_a = -3012.903$
 EDGE -B-
 Bending Moment, $M_b = -0.00055925$
 Shear Force, $V_b = 3012.903$
 BOTH EDGES
 Axial Force, $F = -4665.726$
 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: $As_{mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 376230.192$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 376230.192$
 $V_{Col} = 376230.192$
 $knl = 1.00$
 $displacement_ductility_demand = 0.06549538$

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).

$\gamma = 1$ (normal-weight concrete)
 $f'_c = 20.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 0.00055925$
 $V_u = 3012.903$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4665.726$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 263893.783$
 $A_v = 157079.633$
 $f_y = 420.00$
 $s = 100.00$
 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: $V_s + V_f \leq 297085.704$
 $b_w = 250.00$

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 $\theta_r = 6.7419844E-005$
 $\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00102938$ ((4.29), Biskinis Phd))
 $M_y = 2.0703E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.726$
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \min(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 7.9424748E-006$
with $f_y = 525.00$
 $d = 457.00$
 $\phi_y = 0.27680192$
 $A = 0.01811617$
 $B = 0.00994561$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.726$
 $b = 250.00$
 $\phi_y = 0.0940919$
 $\phi_{y_comp} = 1.6615364E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $\phi_y = 0.27625441$
 $A = 0.01794104$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

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

Calculation No. 14

column C1, Floor 1

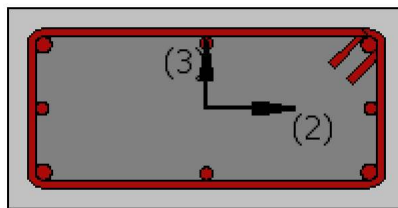
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\gamma = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.29154496$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3221E+008$

$\mu_{u1+} = 1.3221E+008$, 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

$\mu_{u1-} = 1.3221E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3221E+008$

$\mu_{u2+} = 1.3221E+008$, 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

$\mu_{u2-} = 1.3221E+008$, 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_{u1+}

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

$\mu_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
fywe = 656.25
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176

2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176

v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00
d = 177.00
d' = 13.00

```

fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

```

```

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 = 656.25
fce = 30.00
From ((5.A5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25

```

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb,min)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{2+}

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

$\mu = 0.0002015$

$\mu_u = 1.3221 \times 10^{-8}$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

μ_{ue} (5.4c) = 0.00377606

μ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\mu_c = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{u1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$,

For calculation of $\mu_{u1_nominal}$ 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 $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

```

fy2 = 656.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    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/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 656.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 0.0002015
Mu = 1.3221E+008

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi u^* = \text{shear_factor} * \text{Max}(\phi u, \phi c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi u = 0.00595799$$

$$\phi u_e (5.4c) = 0.00377606$$

$$\phi a_s ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi c = 0.00240019$$

$$\phi c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_{1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 656.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

```

ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Co1} ((10.3), \text{ASCE } 41-17) = knl * V_{Co10}$

$V_{Co10} = 302309.152$

$knl = 1$ (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)

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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 <= 363854.192
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 302309.152
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 302309.152
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' = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 6.1816411E-012
Vu = 7.3920505E-032
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 164933.614
Av = 157079.633
fy = 525.00
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 <= 363854.192
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, = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 25742.96
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
New material: Steel Strength, fs = 1.25*fsm = 656.25

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.04002
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 4.5261760E-048$
EDGE -B-
Shear Force, $V_b = -4.5261760E-048$
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 , $V_e/V_r = 0.47299706$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 3.3151E+008$
 $Mu_{1+} = 3.3151E+008$, 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
 $Mu_{1-} = 3.3151E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 3.3151E+008$
 $Mu_{2+} = 3.3151E+008$, 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
 $Mu_{2-} = 3.3151E+008$, 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:

$$\phi_u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.00595799$$

$$\phi_{ue}(5.4c) = 0.00377606$$

$$\phi_{ase}((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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 = 656.25
 fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019
 c = confinement factor = 1.04002

y1 = 0.0025
 sh1 = 0.008
 ft1 = 787.50
 fy1 = 656.25
 su1 = 0.032

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

lo/lou,min = lb/d = 1.00

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 = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025
 sh2 = 0.008
 ft2 = 787.50
 fy2 = 656.25
 su2 = 0.032

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

lo/lou,min = lb/lb,min = 1.00

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 = 656.25

with Es2 = Es = 200000.00

yv = 0.0025
 shv = 0.008
 ftv = 787.50
 fyv = 656.25
 suv = 0.032

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

lo/lou,min = lb/d = 1.00

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/d)^ 2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823

2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.14815151$
 $Mu = MR_c (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.2199924E-005$
 $Mu = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00595799$
 $we (5.4c) = 0.00377606$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$

$psh,x (5.4d) = 0.00314159$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00628319$
 $A_{sh} = A_{stir}*ns = 78.53982$
 No stirups, $ns = 2.00$
 $bk = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5A5), TBDY), TBDY: $cc = 0.00240019$

```

c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb,min)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied

```

--->

$$su(4.9) = 0.14815151$$

$$Mu = MRc(4.14) = 3.3151E+008$$

$$u = su(4.1) = 8.2199924E-005$$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Mu_{2+}

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

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$we(5.4c) = 0.00377606$$

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

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

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 500.00$$

$$psh, y(5.4d) = 0.00628319$$

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

$$lo/lo, \min = lb/d = 1.00$$

$$su1 = 0.4 * esu1_{\text{nominal}}((5.5), TBDY) = 0.032$$

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

For calculation of $esu1_{\text{nominal}}$ $y1, sh1, ft1, fy1$, 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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
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/d)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.15879823
2 = Asl,com/(b*d)*(fs2/fc) = 0.15879823
v = Asl,mid/(b*d)*(fsv/fc) = 0.07699308
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22362502
2 = Asl,com/(b*d)*(fs2/fc) = 0.22362502
v = Asl,mid/(b*d)*(fsv/fc) = 0.10842425
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14815151
Mu = MRc (4.14) = 3.3151E+008
u = su (4.1) = 8.2199924E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

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

$$\phi_u = 8.2199924E-005$$

$$\mu_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_{co} (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.00595799$$

$$\phi_{we} (5.4c) = 0.00377606$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = f_{s1}/1.2$, from table 5.1, TB DY.

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

$$\text{with } f_{s1} = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of $esu2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = f_{s2}/1.2$, from table 5.1, TB DY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/d = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
 From table 5A.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 $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.15879823$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.15879823$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.07699308$
 and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc \text{ (5A.2, TBDY)} = 31.20058$
 $cc \text{ (5A.5, TBDY)} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.22362502$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.22362502$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
 --->

$su \text{ (4.9)} = 0.14815151$
 $Mu = MRc \text{ (4.14)} = 3.3151E+008$
 $u = su \text{ (4.1)} = 8.2199924E-005$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 467242.766$

Calculation of Shear Strength at edge 1, $Vr1 = 467242.766$

$Vr1 = VCol \text{ ((10.3), ASCE 41-17)} = knl \cdot VColO$

$VColO = 467242.766$

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

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

$= 1$ (normal-weight concrete)
 $fc' = 30.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 \cdot h = 400.00$
 $Nu = 4666.932$

Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 329867.229
Av = 157079.633
fy = 525.00
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 <= 363854.192
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 467242.766
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 467242.766
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' = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 3.6217549E-012
Vu = 4.5261760E-048
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 329867.229
Av = 157079.633
fy = 525.00
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 <= 363854.192
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: rcrcs

Constant Properties

Knowledge Factor, = 0.85
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
New material of Primary Member: Concrete Strength, fc = fcm = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 525.00
Concrete Elasticity, Ec = 25742.96
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
Primary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 7.2657463E-011$
Shear Force, $V2 = 3012.903$
Shear Force, $V3 = 2.6198972E-013$
Axial Force, $F = -4665.726$
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: $As_{mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.05034923$
 $u = y + p = 0.05034923$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00923029$ ((4.29), Biskinis Phd))
 $M_y = 9.2818E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 5.0279E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.726$
 $E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 1.8256820E-005$
with $f_y = 525.00$
 $d = 207.00$
 $y = 0.30540153$
 $A = 0.0199978$
 $B = 0.01210998$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.726$
 $b = 500.00$
 $" = 0.20772947$
 $y_{comp} = 3.3230728E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.3049475$
 $A = 0.01980448$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

- Calculation of ρ -

From table 10-8: $\rho = 0.04111895$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_{yE}/V_{ColOE} = 0.29154496$

$d = 207.00$

$s = 0.00$

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

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

$b_w = 500.00$

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

where $f = 2 \cdot t_f/b_w$ 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.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{ytE} = f_{ylE} = 0.00$

$\rho_l = \text{Area_Tot_Long_Rein}/(b \cdot d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

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

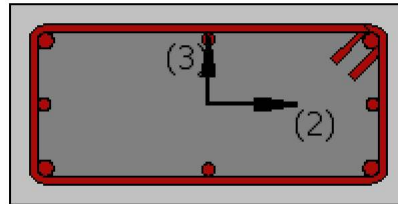
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

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).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 7.1383242E-010$

Shear Force, $V_a = -2.6198972E-013$

EDGE -B-

Bending Moment, $M_b = 7.2657463E-011$

Shear Force, $V_b = 2.6198972E-013$

BOTH EDGES

Axial Force, $F = -4665.726$

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: $As_{l,ten} = 829.3805$

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

-Middle: $As_{l,mid} = 402.1239$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 244283.30$

$V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 244283.30$

$V_{Col} = 244283.30$

$knl = 1.00$

$displacement_ductility_demand = 0.00$

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)

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

$M/Vd = 2.00$

$\mu_u = 7.2657463E-011$

$V_u = 2.6198972E-013$

$d = 0.8 \cdot h = 200.00$

$N_u = 4665.726$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 131946.891$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

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: $V_s + V_f \leq 297085.704$

$bw = 500.00$

$displacement_ductility_demand$ is calculated as γ / y

- Calculation of γ / y for END B -

for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 1.6647448E-020$

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.00923029 ((4.29), Biskinis Phd))$

$M_y = 9.2818E+007$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$

$factor = 0.30$

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.726$

$E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \min(\gamma_{ten}, \gamma_{com})$

$\gamma_{ten} = 1.8256820E-005$

with $f_y = 525.00$

$d = 207.00$

$\gamma = 0.30540153$

$A = 0.0199978$

$B = 0.01210998$

with $pt = 0.00801334$

$pc = 0.00801334$

$pv = 0.00388525$

$N = 4665.726$

b = 500.00
" = 0.20772947
y_comp = 3.3230728E-005
with fc = 30.00
Ec = 25742.96
y = 0.3049475
A = 0.01980448
B = 0.01202411
with Es = 200000.00

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

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

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

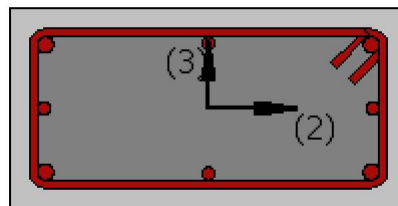
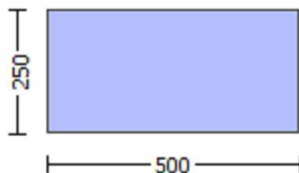
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (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, = 0.85

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.3920505E-032$

EDGE -B-

Shear Force, $V_b = 7.3920505E-032$

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, $V_e/V_r = 0.29154496$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.3221E+008$

$\mu_{1+} = 1.3221E+008$, 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

$\mu_{1-} = 1.3221E+008$, 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

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.3221E+008$

$\mu_{2+} = 1.3221E+008$, 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

$\mu_{2-} = 1.3221E+008$, 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:

$\mu = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00595799$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00595799$$

$$\phi_w (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TB DY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00240019$$

$$\phi_c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 787.50$$

$$f_{y1} = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu_1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered
characteristic value $fsy_1 = f_s/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 787.50$$

$$f_{y2} = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_2_{nominal} = 0.08,$$

For calculation of $esu_2_{nominal}$ and $y_2, sh_2, f_{t2}, f_{y2}$, it is considered
characteristic value $fsy_2 = f_s/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = f_s = 656.25$$

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

$$y_v = 0.0025$$

```

shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    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 = 656.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
    2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
    c = confinement factor = 1.04002
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
    2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 0.0002015
Mu = 1.3221E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00

```

ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159

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 = 656.25
fce = 30.00
From ((5.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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 = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25

```

with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23279566
Mu = MRc (4.14) = 1.3221E+008
u = su (4.1) = 0.0002015
-----

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

Calculation of Mu2+
-----
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 0.0002015
Mu = 1.3221E+008
-----

with full section properties:
b = 500.00
d = 207.00
d' = 43.00
v = 0.00150304
N = 4666.932
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00595799
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00595799
we (5.4c) = 0.00377606
ase ((5.4d), TBDY) = 0.05494666
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.00314159
-----
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 = 656.25
fce = 30.00
From ((5A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002
y1 = 0.0025
sh1 = 0.008
ft1 = 787.50
fy1 = 656.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 656.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 787.50
fy2 = 656.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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,min)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 656.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 787.50
fyv = 656.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
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/lb,min)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 656.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176
2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176
v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 31.20058
cc (5A.5, TBDY) = 0.00240019
c = confinement factor = 1.04002
1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708
2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708
v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889
Case/Assumption: Unconfinedsd full section - Steel rupture

```

' does not satisfy Eq. (4.3)

--->

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

--->

$\mu_u(4.9) = 0.23279566$

$\mu_u = M_{Rc}(4.14) = 1.3221E+008$

$u = \mu_u(4.1) = 0.0002015$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of μ_{u2} -

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

$u = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha(5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

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

From (5.4b), TBDY: $\mu_u = 0.00595799$

$\mu_{ue}(5.4c) = 0.00377606$

$\mu_{ase}((5.4d), TBDY) = 0.05494666$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5A5), TBDY), TBDY: $\mu_c = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$f_{t1} = 787.50$

$f_{y1} = 656.25$

$\mu_{u1} = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$I_o/I_{ou,min} = I_b/I_d = 1.00$

$\mu_{u1} = 0.4 * \mu_{u1_nominal}((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\mu_{u1_nominal} = 0.08$,

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 656.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 787.50$
 $fy2 = 656.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 656.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 787.50$
 $fyv = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
 From table 5A.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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 656.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.17529176$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.17529176$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08498995$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.23295708$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.23295708$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11294889$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.23279566$
 $Mu = MRc (4.14) = 1.3221E+008$
 $u = su (4.1) = 0.0002015$

Calculation of ratio lb/ld

Adequate Lap Length: $lb/ld \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 302309.152$

$k_{nl} = 1$ (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)

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.1816411E-012$

$V_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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: $V_s + V_f \leq 363854.192$

$b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 302309.152$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 302309.152$

$k_{nl} = 1$ (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)

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 6.1816411E-012$

$V_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

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: $V_s + V_f \leq 363854.192$

$b_w = 500.00$

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: rcrcs

Constant Properties

Knowledge Factor, $\phi = 0.85$

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

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

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

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 4.5261760E-048$

EDGE -B-

Shear Force, $V_b = -4.5261760E-048$

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: $As_{l,com} = 829.3805$

-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.47299706$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 3.3151E+008$

$\mu_{u1+} = 3.3151E+008$, 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

$\mu_{u1-} = 3.3151E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 3.3151E+008$

$\mu_{u2+} = 3.3151E+008$, 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

$\mu_{u2-} = 3.3151E+008$, 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_{u1+}

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

$$\phi_u = 8.2199924E-005$$

$$\mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we} (5.4c) = 0.00377606$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

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

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

For calculation of $esu1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = f_s/1.2$, 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.

$$\text{with } fs_1 = f_s = 656.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$$

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

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

For calculation of $esu2_{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered

characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{s2} = f_s = 656.25$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 656.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.14815151$
 $Mu = MR_c (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of $Mu1$ -

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

$u = 8.2199924E-005$
 $Mu = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

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

From (5.4b), TBDY: $c_u = 0.00595799$

w_e (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 500.00$

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

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

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

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

with $fs_1 = fs = 656.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$fy_2 = 656.25$

$su_2 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

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

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

with $fs_2 = fs = 656.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$suv = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

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

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

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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 656.25$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.14815151

$Mu = MR_c$ (4.14) = 3.3151E+008

$u = su$ (4.1) = 8.2199924E-005

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_{2+}

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

$u = 8.2199924E-005$

$Mu = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

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

From (5.4b), TBDY: $cu = 0.00595799$

w_e (5.4c) = 0.00377606

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

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00314159$

psh_x (5.4d) = 0.00314159

$A_{sh} = A_{stir} \cdot n_s = 78.53982$

No stirups, $n_s = 2.00$

$bk = 500.00$

psh_y (5.4d) = 0.00628319

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From } ((5.5), \text{TDY}), \text{TDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$su1 = 0.4 * esu1_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

For calculation of $esu1_{\text{nominal}}$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TDY.

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

$$\text{with } fs1 = fs = 656.25$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

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

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su2 = 0.4 * esu2_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

For calculation of $esu2_{\text{nominal}}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TDY.

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

$$\text{with } fs2 = fs = 656.25$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{\text{nominal}} ((5.5), \text{TDY}) = 0.032$$

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

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

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

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

$$\text{with } fsv = fs = 656.25$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.15879823$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.15879823$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TDY}) = 31.20058$$

$$cc (5A.5, \text{TDY}) = 0.00240019$$

$c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->

$\mu_u(4.9) = 0.14815151$
 $\mu_u = M_{Rc}(4.14) = 3.3151E+008$
 $u = \mu_u(4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{u2} -

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

$u = 8.2199924E-005$
 $\mu_u = 3.3151E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00136161$
 $N = 4666.932$
 $f_c = 30.00$
 $\alpha_{co}(5A.5, \text{TBDY}) = 0.002$
 Final value of μ_{cu} : $\mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_{cu} = 0.00595799$
 $\mu_{we}(5.4c) = 0.00377606$
 $\mu_{ase}((5.4d), \text{TBDY}) = 0.05494666$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00314159$

$\mu_{psh,x}(5.4d) = 0.00314159$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\mu_{psh,y}(5.4d) = 0.00628319$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 100.00$
 $f_{ywe} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A5), TBDY), TBDY: $\mu_{cc} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 787.50$
 $fy_1 = 656.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs_1 = fs = 656.25$
with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 787.50$
 $fy_2 = 656.25$
 $su_2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs_2 = fs = 656.25$
with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 787.50$
 $fy_v = 656.25$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 656.25$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.15879823$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.15879823$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.07699308$
and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl_{ten}/(b * d) * (fs_1/fc) = 0.22362502$
 $2 = Asl_{com}/(b * d) * (fs_2/fc) = 0.22362502$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.10842425$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.14815151$
 $Mu = MRc (4.14) = 3.3151E+008$
 $u = su (4.1) = 8.2199924E-005$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8^* h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 363854.192$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 467242.766$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$ (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)

$f'_c = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8^* h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 363854.192$

$b_w = 250.00$

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: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\phi = 0.85$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d > 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -0.00055925$

Shear Force, $V_2 = 3012.903$

Shear Force, $V_3 = 2.6198972E-013$

Axial Force, $F = -4665.726$

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: $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^* u = 0.05106217$

$u = y + p = 0.05106217$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00102938$ ((4.29), Biskinis Phd))

$M_y = 2.0703E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$

factor = 0.30

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.726$

$E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 7.9424748\text{E-}006$
with $f_y = 525.00$
 $d = 457.00$
 $\gamma = 0.27680192$
 $A = 0.01811617$
 $B = 0.00994561$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.726$
 $b = 250.00$
 $\gamma = 0.0940919$
 $y_{\text{comp}} = 1.6615364\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $\gamma = 0.27625441$
 $A = 0.01794104$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.05003279$

with:

- Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$

shear control ratio $V_y E / V_{col} E = 0.47299706$

$d = 457.00$

$s = 0.00$

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

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

$b_w = 250.00$

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

where $f = 2 \cdot t_f / b_w$ 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.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{ytE} = f_{ylE} = 0.00$

$p_l = \text{Area_Tot_Long_Rein} / (b \cdot d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 30.00$

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

At local axis: 3

Integration Section: (b)