

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

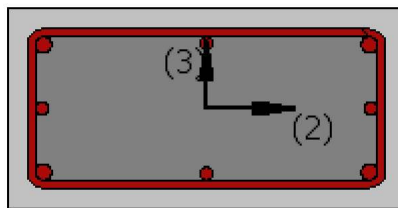
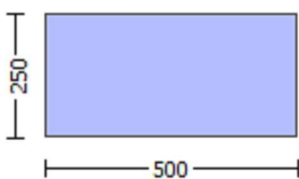
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity 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, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

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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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

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

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

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Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -9.3055E+006$

Shear Force, $V_a = -3075.705$

EDGE -B-

Bending Moment, $M_b = 75969.712$

Shear Force, $V_b = 3075.705$

BOTH EDGES

Axial Force, $F = -4808.847$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com} = 829.3805$

-Middle: $A_{sl,mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 170158.314$

V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoI} = 170158.314$

$V_{CoI} = 170158.314$

$k_n l = 1.00$

displacement_ductility_demand = 0.01498372

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

= 1 (normal-weight concrete)

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

$M / V_d = 4.00$

$M_u = 9.3055E+006$

$V_u = 3075.705$

$d = 0.8 \cdot h = 400.00$

$N_u = 4808.847$

$A_g = 125000.00$

From ((11.5.4.8), ACI 318-14: $V_s = 119679.72$

$A_v = 157079.633$

$f_y = 400.00$

$s = 210.00$

V_s is multiplied by $CoI = 1.00$

$s/d = 0.525$

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

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

displacement_ductility_demand is calculated as ϕ_y

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

From analysis, chord rotation $\theta = 0.00016016$
 $\phi_y = (M_y * L_s / 3) / E_{eff} = 0.01068896$ ((4.29), Biskinis Phd))
 $M_y = 1.7405E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3025.481
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4808.847$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \min(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 6.9053083E-006$
with $f_y = 444.44$
 $d = 457.00$
 $\phi_y = 0.29581971$
 $A = 0.01813308$
 $B = 0.00996253$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4808.847$
 $b = 250.00$
 $\phi_{y_com} = 1.2695706E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $\phi_y = 0.29520017$
 $A = 0.0179155$
 $B = 0.00986782$
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

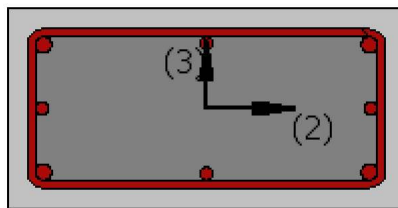
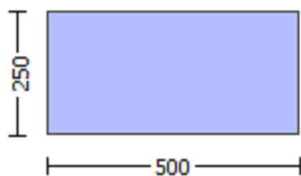
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_u)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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 , $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.1226E+008$

$\mu_{u1+} = 1.1226E+008$, 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

$\mu_{u1-} = 1.1226E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.1226E+008$

$\mu_{u2+} = 1.1226E+008$, 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

$\mu_{u2-} = 1.1226E+008$, 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:

$\mu_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00425603$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00425603$

ϕ_{we} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.001496$

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

$\phi_{psh,x}$ (5.4d) = 0.001496

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

No stirrups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
fce = 20.00

From ((5.A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00231479

sh1 = 0.008

ft1 = 666.66

fy1 = 555.55

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, ASCE 41-17.

with fs1 = fs = 555.55

with Es1 = Es = 200000.00

y2 = 0.00231479

sh2 = 0.008

ft2 = 666.66

fy2 = 555.55

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, ASCE 41-17.

with fs2 = fs = 555.55

with Es2 = Es = 200000.00

yv = 0.00231479

shv = 0.008

ftv = 666.66

fyv = 555.55

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, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049

2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049

v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266

and confined core properties:

b = 440.00

$d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29581556$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.29581556$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.14342573$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

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

$su (4.9) = 0.24243176$
 $Mu = MR_c (4.14) = 1.1226E+008$
 $u = su (4.1) = 0.00020406$

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:
 $u = 0.00020406$
 $Mu = 1.1226E+008$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$

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

$psh,x (5.4d) = 0.001496$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $bk = 250.00$

$s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$

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y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
    with fs1 = fs = 555.55
    with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
    with fs2 = fs = 555.55
    with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu₂₊

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

u = 0.00020406
Mu = 1.1226E+008

with full section properties:

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
f_c = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00
ho = 190.00
bi₂ = 459400.00
psh,min = Min(psh,x , psh,y) = 0.001496
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.001496
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
f_{ce} = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y₁ = 0.00231479
sh₁ = 0.008
ft₁ = 666.66
fy₁ = 555.55
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/l_d = 1.00
su₁ = 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 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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.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, ASCE 41-17.
 with $fsv = fs = 555.55$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.22259049$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.22259049$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.10792266$

and confined core properties:

$b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.29581556$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.29581556$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su (4.9) = 0.24243176$

$Mu = MRc (4.14) = 1.1226E+008$

$u = su (4.1) = 0.00020406$

Calculation of ratio lb/ld

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

Calculation of $Mu2$ -

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

$$\phi_u = 0.00020406$$

$$\mu = 1.1226 \times 10^8$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$\nu = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00425603$$

$$\phi_{we} (5.4c) = 0.00035724$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.001496$$

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

$$\phi_{psh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{psh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

$$\text{Shear_factor} = 1.00$$

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

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

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

For calculation of $esu1_{nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

$y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

$$\text{Shear_factor} = 1.00$$

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

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

From table 5A.1, TBDY: $es_{u2_nominal} = 0.08$,
 For calculation of $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 555.55$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00231479$
 $sh_v = 0.008$
 $ft_v = 666.66$
 $fy_v = 555.55$
 $suv = 0.032$
 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
 $lo/lou, min = lb/d = 1.00$
 $suv = 0.4 \cdot es_{u2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,
 considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $es_{uv_nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = fs = 555.55$
 with $Es_v = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs_1 / fc) = 0.22259049$
 $2 = Asl, com / (b \cdot d) \cdot (fs_2 / fc) = 0.22259049$
 $v = Asl, mid / (b \cdot d) \cdot (fs_v / fc) = 0.10792266$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs_1 / fc) = 0.29581556$
 $2 = Asl, com / (b \cdot d) \cdot (fs_2 / fc) = 0.29581556$
 $v = Asl, mid / (b \cdot d) \cdot (fs_v / fc) = 0.14342573$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.24243176$
 $Mu = MRc (4.14) = 1.1226E+008$
 $u = su (4.1) = 0.00020406$

 Calculation of ratio lb/d

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

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 112732.921$

Calculation of Shear Strength at edge 1, $V_{r1} = 112732.921$

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

$V_{Col0} = 112732.921$

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

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

 $= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$Mu = 1.3332753E-012$

$V_u = 7.2890426E-033$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 0.00$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 210.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 1.05$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 112732.921$
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_n l \cdot V_{\text{Col}0}$
 $V_{\text{Col}0} = 112732.921$
 $k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 $f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 1.3332753E-012$
 $V_u = 7.2890426E-033$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 0.00$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 210.00$
 V_s is multiplied by $\text{Col} = 0.00$
 $s/d = 1.05$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $b_w = 500.00$

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

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

Constant Properties

Knowledge Factor, $= 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$
 #####

Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.00
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u}, \min > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.0640763E-031$
EDGE -B-
Shear Force, $V_b = -1.0640763E-031$
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, $V_e/V_r = 0.76584669$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.8226E+008$
 $\mu_{u1+} = 2.8226E+008$, 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
 $\mu_{u1-} = 2.8226E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.8226E+008$
 $\mu_{u2+} = 2.8226E+008$, 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
 $\mu_{u2-} = 2.8226E+008$, 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:
 $\phi_u = 8.2672130E-005$
 $M_u = 2.8226E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \max(\phi_{cu}, \phi_{cc}) = 0.00425603$

The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.00425603$
 w_e (5.4c) = 0.00035724
 a_{se} ((5.4d), TBDY) = 0.02865579
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$
 Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x}$ (5.4d) = 0.001496
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

 $p_{sh,y}$ (5.4d) = 0.00299199
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

 $s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $c_c = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00231479$
 $sh_1 = 0.008$
 $ft_1 = 666.66$
 $fy_1 = 555.55$
 $su_1 = 0.032$
 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
 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, ASCE 41-17.
 with $fs_1 = fs = 555.55$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00231479$
 $sh_2 = 0.008$
 $ft_2 = 666.66$
 $fy_2 = 555.55$
 $su_2 = 0.032$
 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
 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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = fs = 555.55$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00231479$
 $sh_v = 0.008$
 $ft_v = 666.66$
 $fy_v = 555.55$
 $su_v = 0.032$
 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
 $l_o/l_{ou,min} = l_b/l_d = 1.00$

$\text{suv} = 0.4 \cdot \text{esuv_nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $\text{esuv_nominal} = 0.08$,
 considering characteristic value $\text{fsy} = \text{fsv}/1.2$, from table 5.1, TBDY
 For calculation of esuv_nominal and yv , shv , ftv , fyv , it is considered
 characteristic value $\text{fsy} = \text{fsv}/1.2$, from table 5.1, TBDY.
 y1 , sh1 , ft1 , fy1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.
 with $\text{fsv} = \text{fs} = 555.55$
 with $\text{Esv} = \text{Es} = 200000.00$
 $1 = \text{Asl,ten}/(\text{b} \cdot \text{d}) \cdot (\text{fs1}/\text{fc}) = 0.20164653$
 $2 = \text{Asl,com}/(\text{b} \cdot \text{d}) \cdot (\text{fs2}/\text{fc}) = 0.20164653$
 $v = \text{Asl,mid}/(\text{b} \cdot \text{d}) \cdot (\text{fsv}/\text{fc}) = 0.09776801$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $\text{fcc} (5A.2, \text{TBDY}) = 20.00$
 $\text{cc} (5A.5, \text{TBDY}) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = \text{Asl,ten}/(\text{b} \cdot \text{d}) \cdot (\text{fs1}/\text{fc}) = 0.28396544$
 $2 = \text{Asl,com}/(\text{b} \cdot \text{d}) \cdot (\text{fs2}/\text{fc}) = 0.28396544$
 $v = \text{Asl,mid}/(\text{b} \cdot \text{d}) \cdot (\text{fsv}/\text{fc}) = 0.13768021$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $\text{su} (4.9) = 0.15301708$
 $\text{Mu} = \text{MRc} (4.14) = 2.8226\text{E}+008$
 $u = \text{su} (4.1) = 8.2672130\text{E}-005$

 Calculation of ratio lb/ld

 Adequate Lap Length: $\text{lb}/\text{ld} \geq 1$

 Calculation of Mu1 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.2672130\text{E}-005$
 $\text{Mu} = 2.8226\text{E}+008$

 with full section properties:
 $b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $\text{fc} = 20.00$
 $\text{co} (5A.5, \text{TBDY}) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $w_e (5.4c) = 0.00035724$
 $a_{se} ((5.4d), \text{TBDY}) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $\text{psh,min} = \text{Min}(\text{psh,x}, \text{psh,y}) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without
 earthquake detailing (90° closed stirrups)

 $\text{psh,x} (5.4d) = 0.001496$
 $\text{Ash} = \text{Astir} \cdot n_s = 78.53982$

No stirrups, $n_s = 2.00$
 $b_k = 500.00$

 $p_{sh,y} (5.4d) = 0.00299199$
 $A_{sh} = A_{stir} * n_s = 78.53982$
No stirrups, $n_s = 2.00$
 $b_k = 250.00$

 $s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
From ((5.A.5), TBDY), TBDY: $c_c = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00231479$
 $sh_1 = 0.008$
 $ft_1 = 666.66$
 $fy_1 = 555.55$
 $su_1 = 0.032$
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 $fsy_1 = f_s/1.2$, 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, ASCE 41-17.
with $fs_1 = f_s = 555.55$
with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.00231479$
 $sh_2 = 0.008$
 $ft_2 = 666.66$
 $fy_2 = 555.55$
 $su_2 = 0.032$
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 $fsy_2 = f_s/1.2$, 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, ASCE 41-17.
with $fs_2 = f_s = 555.55$
with $E_{s2} = E_s = 200000.00$
 $y_v = 0.00231479$
 $sh_v = 0.008$
 $ft_v = 666.66$
 $fy_v = 555.55$
 $suv = 0.032$
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 $fsyv = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $f_{sv} = f_s = 555.55$
with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.20164653$
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.20164653$
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.09776801$
and confined core properties:
 $b = 190.00$

$d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.28396544$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.28396544$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.13768021$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

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

$s_u (4.9) = 0.15301708$
 $M_u = M_{Rc} (4.14) = 2.8226E+008$
 $u = s_u (4.1) = 8.2672130E-005$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.2672130E-005$
 $M_u = 2.8226E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $w_e (5.4c) = 0.00035724$
 $a_{se} ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$

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

$p_{sh,x} (5.4d) = 0.001496$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$p_{sh,y} (5.4d) = 0.00299199$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$

```

y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu₂-

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

u = 8.2672130E-005
Mu = 2.8226E+008

with full section properties:

b = 250.00
d = 457.00
d' = 43.00
v = 0.00204242
N = 4666.932
f_c = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.001496
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.001496
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 500.00

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirrups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
f_{ce} = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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/l_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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.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, ASCE 41-17.
 with $fsv = fs = 555.55$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.20164653$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.20164653$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.09776801$

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.28396544$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.28396544$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.13768021$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

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

$su (4.9) = 0.15301708$

$Mu = MRc (4.14) = 2.8226E+008$

$u = su (4.1) = 8.2672130E-005$

 Calculation of ratio lb/ld

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

 Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

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

$V_{Col0} = 245709.058$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$\nu_u = 1.0640763E-031$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.525$

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

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

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 245709.058$

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

$V_{Col0} = 245709.058$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$\nu_u = 1.0640763E-031$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.525$

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

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

$b_w = 250.00$

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -3.8643257E-011$
 Shear Force, $V_2 = -3075.705$
 Shear Force, $V_3 = 2.0575461E-014$
 Axial Force, $F = -4808.847$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 829.3805$
 -Compression: $A_{st,com} = 829.3805$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $D_bL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \phi \cdot u = 0.01295517$
 $u = y + p = 0.01295517$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00944921$ ((4.29), Biskinis Phd))
 $M_y = 7.7583E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4808.847$
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 1.5935853E-005$
 with $f_y = 444.44$
 $d = 207.00$
 $y = 0.32634506$

$A = 0.02001647$
 $B = 0.01212865$
 with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4808.847$
 $b = 500.00$
 $\mu = 0.20772947$
 $y_{comp} = 2.5391411E-005$
 with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32586105$
 $A = 0.01977629$
 $B = 0.01202411$
 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: $p = 0.00350596$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$
 shear control ratio $V_y E / V_{col} E = 0.66388728$

$d = 207.00$

$s = 0.00$

$t = A_v / (b_w s) + 2 t_f / b_w (f_{fe} / f_s) = 0.001496$

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

$b_w = 500.00$

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

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

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

$N_{UD} = 4808.847$

$A_g = 125000.00$

$f_{cE} = 20.00$

$f_{yE} = f_{yI} = 444.44$

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

$b = 500.00$

$d = 207.00$

$f_{cE} = 20.00$

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

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

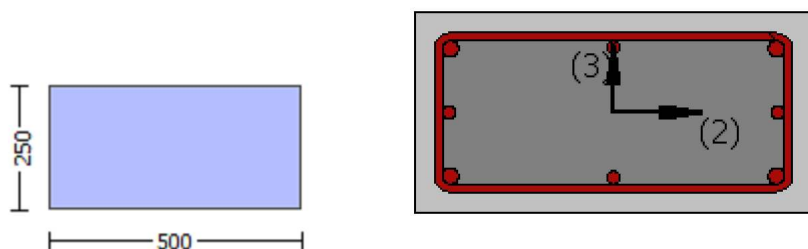
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity 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, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -3.8643257E-011$

Shear Force, $V_a = 2.0575461E-014$
 EDGE -B-
 Bending Moment, $M_b = -2.3093644E-011$
 Shear Force, $V_b = -2.0575461E-014$
 BOTH EDGES
 Axial Force, $F = -4808.847$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 829.3805$
 -Compression: $A_{sl,com} = 829.3805$
 -Middle: $A_{sl,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 100957.188$
 $V_n ((10.3), ASCE 41-17) = knl * V_{ColO} = 100957.188$
 $V_{Col} = 100957.188$
 $knl = 1.00$
 $displacement_ductility_demand = 0.00$

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

$= 1$ (normal-weight concrete)
 $f'_c = 16.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 3.8643257E-011$
 $V_u = 2.0575461E-014$
 $d = 0.8 * h = 200.00$
 $N_u = 4808.847$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 0.00$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 1.05$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 500.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 7.0354334E-022$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00944921 ((4.29), Biskinis Phd)$
 $M_y = 7.7583E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f'_c = 20.00$
 $N = 4808.847$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.5935853\text{E-}005$
with $f_y = 444.44$
 $d = 207.00$
 $y = 0.32634506$
 $A = 0.02001647$
 $B = 0.01212865$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4808.847$
 $b = 500.00$
 $" = 0.20772947$
 $y_{\text{comp}} = 2.5391411\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32586105$
 $A = 0.01977629$
 $B = 0.01202411$
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: (a)

Calculation No. 4

column C1, Floor 1

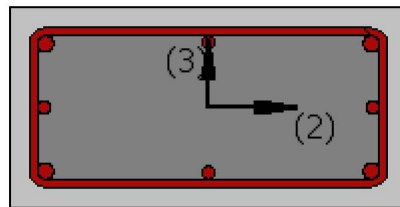
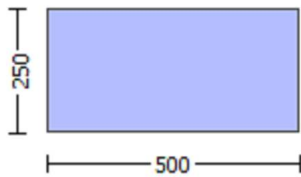
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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 , $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.1226\text{E}+008$

$\mu_{u1+} = 1.1226\text{E}+008$, 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

$\mu_{u1-} = 1.1226\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.1226\text{E}+008$

$\mu_{u2+} = 1.1226\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 1.1226\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

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

$\mu_u = 0.00020406$

$\mu_u = 1.1226\text{E}+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$

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

From (5.4b), TBDY: $\mu_u = 0.00425603$

$w_e (5.4c) = 0.00035724$

$a_{se} ((5.4d), \text{TBDY}) = 0.02865579$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$

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

 $p_{sh,x} (5.4d) = 0.001496$

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$p_{sh,y} (5.4d) = 0.00299199$

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 210.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

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

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

$y_1 = 0.00231479$

$sh_1 = 0.008$

$ft_1 = 666.66$

$fy_1 = 555.55$

$su_1 = 0.032$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

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

Calculation of μ_1 -

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

$$\mu = 0.00020406$$

$$\mu_u = 1.1226 \times 10^{-8}$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$w_e (5.4c) = 0.00035724$$

$$a_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1,nominal} = 0.08$$

For calculation of $s_{u1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_s/1.2$, 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $f_c = 20.00$
 $\phi (5A.5, TBDY) = 0.002$
 Final value of ϕ : $\phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi = 0.00425603$
 $\phi_w (5.4c) = 0.00035724$
 $\phi_{se} ((5.4d), TBDY) = 0.02865579$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_i^2 = 459400.00$
 $\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$
 Expression ((5.4d), TBDY) for $\phi_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{sh,x} (5.4d) = 0.001496$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\phi_{sh,y} (5.4d) = 0.00299199$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
 From ((5A5), TBDY), TBDY: $\phi_c = 0.002$
 $\phi_c = \text{confinement factor} = 1.00$
 $y_1 = 0.00231479$
 $sh_1 = 0.008$
 $ft_1 = 666.66$
 $fy_1 = 555.55$
 $su_1 = 0.032$
 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 $\phi_{sy1} = \phi_s / 1.2$, 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, ASCE 41-17.
 with $\phi_s = f_s = 555.55$
 with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.00231479$
 $sh_2 = 0.008$
 $ft_2 = 666.66$
 $fy_2 = 555.55$
 $su_2 = 0.032$
 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 $\phi_{sy2} = \phi_s / 1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $\phi_s = f_s = 555.55$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00

```

$h_o = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 555.55$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.22259049$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.22259049$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.10792266$

and confined core properties:

$b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.29581556$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.29581556$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

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

$su (4.9) = 0.24243176$

$Mu = MRc (4.14) = 1.1226E+008$

$u = su (4.1) = 0.00020406$

Calculation of ratio lb/d

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 112732.921$

Calculation of Shear Strength at edge 1, $Vr1 = 112732.921$

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

$VCol0 = 112732.921$

$knl = 1$ (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)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 1.3332753E-012$
 $Vu = 7.2890426E-033$
 $d = 0.8 \cdot h = 200.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $Vs = 0.00$
 $Av = 157079.633$
 $fy = 444.44$
 $s = 210.00$
 Vs is multiplied by $Col = 0.00$
 $s/d = 1.05$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 297085.704$
 $bw = 500.00$

Calculation of Shear Strength at edge 2, $Vr2 = 112732.921$

$Vr2 = VCol ((10.3), ASCE 41-17) = knl \cdot VCol0$

$VCol0 = 112732.921$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.0640763E-031$

EDGE -B-

Shear Force, $V_b = -1.0640763E-031$

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, $V_e/V_r = 0.76584669$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.8226E+008$

$Mu_{1+} = 2.8226E+008$, 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

$Mu_{1-} = 2.8226E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.8226E+008$

$Mu_{2+} = 2.8226E+008$, 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

$Mu_{2-} = 2.8226E+008$, 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 Mu_{1+}

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

$\phi_u = 8.2672130E-005$

$M_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

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

From (5.4b), TBDY: $\phi_u = 0.00425603$

ϕ_{we} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00299199

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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

--->

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

--->

$$s_u(4.9) = 0.15301708$$

$$M_u = M_{Rc}(4.14) = 2.8226E+008$$

$$u = s_u(4.1) = 8.2672130E-005$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u1} -

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

$$u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00425603$$

$$\phi_{we}(5.4c) = 0.00035724$$

$$\phi_{ase}((5.4d), \text{TBDY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{sh, min} = \text{Min}(\phi_{sh, x}, \phi_{sh, y}) = 0.001496$$

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

$$\phi_{sh, x}(5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{sh, y}(5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

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

Calculation of μ_{2+}

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

$$\mu = 8.2672130E-005$$

$$\mu_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$\nu = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$\mu_{ue} (5.4c) = 0.00035724$$

$$\mu_{ase} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1,nominal} = 0.08$$

For calculation of $s_{u1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_s/1.2$, 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-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 = 8.2672130E-005

Mu = 2.8226E+008

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
    2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
    v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
    2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
    v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

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

$V_{Co10} = 245709.058$

$knl = 1$ (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)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

s = 210.00
Vs is multiplied by Col = 1.00
s/d = 0.525
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 245709.058
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 245709.058
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0649661E-012
Vu = 1.0640763E-031
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 132976.137
Av = 157079.633
fy = 444.44
s = 210.00
Vs is multiplied by Col = 1.00
s/d = 0.525
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

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

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

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($lb/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -9.3055\text{E}+006$

Shear Force, $V2 = -3075.705$

Shear Force, $V3 = 2.0575461\text{E}-014$

Axial Force, $F = -4808.847$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $Asl_t = 0.00$

-Compression: $Asl_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten} = 829.3805$

-Compression: $Asl_{com} = 829.3805$

-Middle: $Asl_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \quad * u = 0.01398453$

$u = y + p = 0.01398453$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.01068896 ((4.29), \text{Biskinis Phd})$

$My = 1.7405\text{E}+008$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 3025.481

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 1.6421\text{E}+013$

factor = 0.30

$Ag = 125000.00$

$fc' = 20.00$

$N = 4808.847$

$Ec * Ig = 5.4737\text{E}+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 6.9053083\text{E}-006$

with $fy = 444.44$

$d = 457.00$

$y = 0.29581971$

$A = 0.01813308$

$B = 0.00996253$

with $pt = 0.00725935$

$pc = 0.00725935$

$pv = 0.00351968$

$N = 4808.847$

$b = 250.00$

$" = 0.0940919$

$y_{comp} = 1.2695706\text{E}-005$

with $fc = 20.00$

$Ec = 21019.039$

$y = 0.29520017$

$A = 0.0179155$

$B = 0.00986782$

with $Es = 200000.00$

Calculation of ratio lb/d

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

- Calculation of p -

From table 10-8: $p = 0.00329557$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_{yE}/V_{Col0E} = 0.76584669$

$d = 457.00$

$s = 0.00$

$t = A_v/(b_w \cdot s) + 2 \cdot t_f/b_w \cdot (f_{fe}/f_s) = 0.00299199$

$A_v = 157.0796$, 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.

$NUD = 4808.847$

$A_g = 125000.00$

$f_{cE} = 20.00$

$f_{yE} = f_{yE} = 444.44$

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

$b = 250.00$

$d = 457.00$

$f_{cE} = 20.00$

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

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

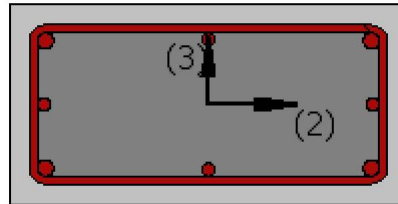
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -9.3055E+006$

Shear Force, $V_a = -3075.705$

EDGE -B-

Bending Moment, $M_b = 75969.712$

Shear Force, $V_b = 3075.705$

BOTH EDGES

Axial Force, $F = -4808.847$

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, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 220636.908$
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col0} = 220636.908$
 $V_{Col} = 220636.908$
 $knl = 1.00$
 $displacement_ductility_demand = 0.08137162$

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

$= 1$ (normal-weight concrete)
 $f'_c = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 75969.712$
 $V_u = 3075.705$
 $d = 0.8 * h = 400.00$
 $N_u = 4808.847$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 119679.72$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.525$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 250.00$

$displacement_ductility_demand$ is calculated as γ / y

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

From analysis, chord rotation $\theta = 8.6245263E-005$
 $\gamma = (M_y * L_s / 3) / E_{eff} = 0.00105989$ ((4.29), Biskinis Phd))
 $M_y = 1.7405E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f'_c = 20.00$
 $N = 4808.847$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \min(\gamma_{ten}, \gamma_{com})$
 $\gamma_{ten} = 6.9053083E-006$
with $f_y = 444.44$
 $d = 457.00$
 $\gamma = 0.29581971$
 $A = 0.01813308$
 $B = 0.00996253$
with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4808.847$

b = 250.00
" = 0.0940919
y_comp = 1.2695706E-005
with fc = 20.00
Ec = 21019.039
y = 0.29520017
A = 0.0179155
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: (b)

Calculation No. 6

column C1, Floor 1

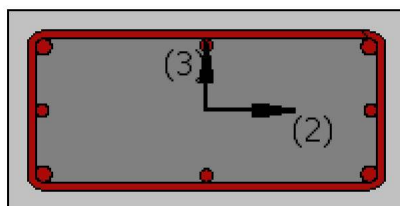
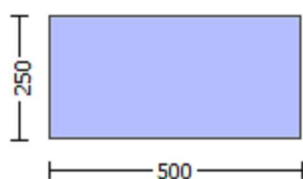
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (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, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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, $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.1226E+008$

$\mu_{1+} = 1.1226E+008$, 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

$\mu_{1-} = 1.1226E+008$, 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

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.1226E+008$

$\mu_{2+} = 1.1226E+008$, 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

$\mu_{2-} = 1.1226E+008$, 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:

$\mu = 0.00020406$

$\mu_u = 1.1226E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \alpha_c = 0.00425603$$

$$\alpha_w (5.4c) = 0.00035724$$

$$\alpha_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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

$$p_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

For calculation of $\alpha_{su1_nominal}$ 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

For calculation of $\alpha_{su2_nominal}$ 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, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 555.55$$

```

with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724

```

$ase((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression $((5.4d), TBDY)$ for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x(5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y(5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From $((5.A5), TBDY)$, $TBDY$: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\epsilon_{sv_nominal}$ and γ_v , ϕ_{sv} , ϕ_{ftv} , ϕ_{fyv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , $\phi_{1,ft}$, $\phi_{1,fy}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 555.55$

with $E_{sv} = E_s = 200000.00$

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22259049$

$2 = A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22259049$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10792266$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

c_c (5A.5, TBDY) = 0.002

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

$1 = A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.29581556$

$2 = A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.29581556$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.24243176

$\mu_u = M_{Rc}$ (4.14) = 1.1226E+008

$u = \mu_u$ (4.1) = 0.00020406

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:

$u = 0.00020406$

$\mu_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

c_c (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, c_c) = 0.00425603$

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

From (5.4b), TBDY: $\mu_u = 0.00425603$

μ_{ue} (5.4c) = 0.00035724

μ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$

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

$\mu_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00231479
sh1 = 0.008

ft1 = 666.66

fy1 = 555.55

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, ASCE 41-17.

with fs1 = fs = 555.55

with Es1 = Es = 200000.00

y2 = 0.00231479

sh2 = 0.008

ft2 = 666.66

fy2 = 555.55

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, ASCE 41-17.

with fs2 = fs = 555.55

with Es2 = Es = 200000.00

yv = 0.00231479

shv = 0.008

ftv = 666.66

fyv = 555.55

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, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049

2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049

v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

```

cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.001496
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without
earthquake detailing (90° closed stirrups)

```

```

psh,x (5.4d) = 0.001496
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

```

```

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

```

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66

```

```

fy1 = 555.55
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, ASCE 41-17.
    with fs1 = fs = 555.55
    with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
    with fs2 = fs = 555.55
    with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
    u = su (4.1) = 0.00020406

```

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 112732.921$

Calculation of Shear Strength at edge 1, $V_{r1} = 112732.921$

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

$V_{Col0} = 112732.921$

$k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $Col = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 112732.921$

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

$V_{Col0} = 112732.921$

$k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $Col = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.0640763E-031$

EDGE -B-

Shear Force, $V_b = -1.0640763E-031$

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, $V_e/V_r = 0.76584669$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.8226E+008$

$\mu_{u1+} = 2.8226E+008$, 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

$\mu_{u1-} = 2.8226E+008$, 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

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.8226E+008$

Mu2+ = 2.8226E+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

Mu2- = 2.8226E+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 Mu1+

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

$$\phi_u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$\nu = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_c) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00425603$$

$$\phi_{we} \text{ (5.4c)} = 0.00035724$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$$

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

$$\phi_{sh,x} \text{ (5.4d)} = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{sh,y} \text{ (5.4d)} = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = fs = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

```

ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
    with fs2 = fs = 555.55
    with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

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 = 8.2672130E-005
Mu = 2.8226E+008

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \alpha_c = 0.00425603$$

$$\alpha_w (5.4c) = 0.00035724$$

$$\alpha_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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

$$p_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

For calculation of $\alpha_{su1_nominal}$ 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

For calculation of $\alpha_{su2_nominal}$ 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, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 555.55$$


```

with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-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 = 8.2672130E-005
Mu = 2.8226E+008

```

with full section properties:

```

b = 250.00
d = 457.00
d' = 43.00
v = 0.00204242
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724

```

$ase((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression $((5.4d), TBDY)$ for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x(5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y(5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From $((5.A5), TBDY)$, $TBDY$: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\epsilon_{suv_nominal}$ and γ_v , ϕ_v , ϕ_{ftv} , ϕ_{fyv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , $\phi_{1,ft1}$, $\phi_{1,fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 555.55$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20164653$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20164653$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.09776801$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

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

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

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.28396544$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.28396544$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.13768021$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$\mu_u \text{ (4.9)} = 0.15301708$

$\mu_u = M_{Rc} \text{ (4.14)} = 2.8226E+008$

$u = \mu_u \text{ (4.1)} = 8.2672130E-005$

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:

$u = 8.2672130E-005$

$\mu_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00425603$

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

From (5.4b), TBDY: $\mu_u = 0.00425603$

$w_e \text{ (5.4c)} = 0.00035724$

$a_{se} \text{ ((5.4d), TBDY)} = 0.02865579$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x} \text{ (5.4d)} = 0.001496$

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00231479
sh1 = 0.008

ft1 = 666.66

fy1 = 555.55

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, ASCE 41-17.

with fs1 = fs = 555.55

with Es1 = Es = 200000.00

y2 = 0.00231479

sh2 = 0.008

ft2 = 666.66

fy2 = 555.55

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, ASCE 41-17.

with fs2 = fs = 555.55

with Es2 = Es = 200000.00

yv = 0.00231479

shv = 0.008

ftv = 666.66

fyv = 555.55

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, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653

2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653

v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.28396544$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.28396544$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.13768021$$

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

--->

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

--->

$$su(4.9) = 0.15301708$$

$$Mu = MRc(4.14) = 2.8226E+008$$

$$u = su(4.1) = 8.2672130E-005$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

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

$$V_{Col0} = 245709.058$$

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

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

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

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

$$M/Vd = 2.00$$

$$Mu = 2.0649661E-012$$

$$Vu = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 132976.137$$

$$A_v = 157079.633$$

$$f_y = 444.44$$

$$s = 210.00$$

$$V_s \text{ is multiplied by } Col = 1.00$$

$$s/d = 0.525$$

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

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

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 245709.058$

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

$$V_{Col0} = 245709.058$$

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

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

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

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

$$M/Vd = 2.00$$

$$Mu = 2.0649661E-012$$

$$Vu = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 210.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.525$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $b_w = 250.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -2.3093644E-011$
Shear Force, $V_2 = 3075.705$
Shear Force, $V_3 = -2.0575461E-014$
Axial Force, $F = -4808.847$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{st,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_bL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \phi \cdot u = 0.01295517$
 $u = y + p = 0.01295517$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00944921$ ((4.29), Biskinis Phd))
 $M_y = 7.7583E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4808.847$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.5935853E-005$
with $f_y = 444.44$
 $d = 207.00$
 $y = 0.32634506$
 $A = 0.02001647$
 $B = 0.01212865$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4808.847$
 $b = 500.00$
 $" = 0.20772947$
 $y_{comp} = 2.5391411E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32586105$
 $A = 0.01977629$
 $B = 0.01202411$
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: $p = 0.00350596$

with:

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

shear control ratio $V_y E / V_{col} E = 0.66388728$

$d = 207.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.001496$

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

$b_w = 500.00$

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

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

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

$N_{UD} = 4808.847$

$A_g = 125000.00$

$f_c E = 20.00$

$f_y E = f_y = 444.44$

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

$b = 500.00$

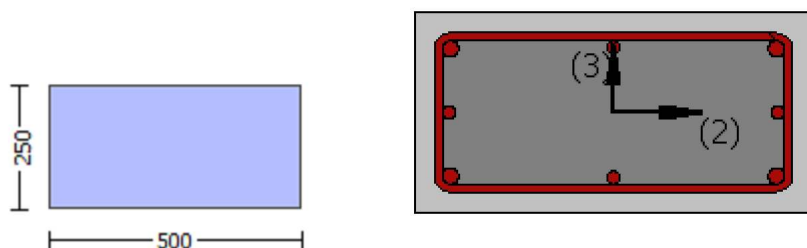
$d = 207.00$

$f_c E = 20.00$

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

Calculation No. 7

column C1, Floor 1
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity VR_d
Edge: End
Local Axis: (3)



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

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of γ for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -3.8643257E-011$
Shear Force, $V_a = 2.0575461E-014$
EDGE -B-
Bending Moment, $M_b = -2.3093644E-011$
Shear Force, $V_b = -2.0575461E-014$
BOTH EDGES
Axial Force, $F = -4808.847$
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, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = V_n = 100957.188$
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col} = 100957.188$
 $V_{Col} = 100957.188$
 $knl = 1.00$
 $displacement_ductility_demand = 0.00$

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

= 1 (normal-weight concrete)
 $f'_c = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 2.3093644E-011$
 $V_u = 2.0575461E-014$
 $d = 0.8 * h = 200.00$
 $N_u = 4808.847$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 0.00$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 1.05$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 500.00$

 $displacement_ductility_demand$ is calculated as $\frac{V_u}{V_n}$

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

From analysis, chord rotation $\theta = 3.0919322E-022$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00944921$ ((4.29), Biskinis Phd))
 $M_y = 7.7583E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4808.847$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 1.5935853E-005$
with $f_y = 444.44$
 $d = 207.00$
 $y = 0.32634506$
 $A = 0.02001647$
 $B = 0.01212865$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4808.847$
 $b = 500.00$
 $\phi = 0.20772947$
 $\phi_{y_comp} = 2.5391411E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32586105$
 $A = 0.01977629$
 $B = 0.01202411$
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

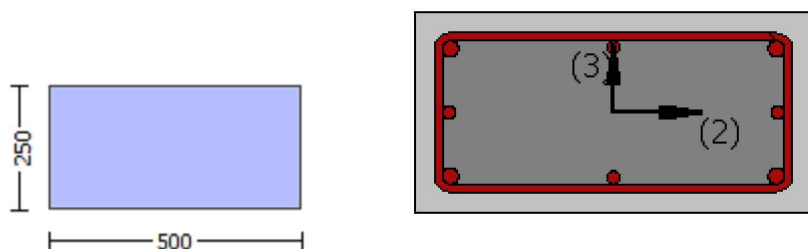
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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, $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$

with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.1226E+008$

$\mu_{u1+} = 1.1226E+008$, 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

$\mu_{u1-} = 1.1226E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.1226E+008$

$\mu_{u2+} = 1.1226E+008$, 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

$\mu_{u2-} = 1.1226E+008$, 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:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

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

From (5.4b), TBDY: $\phi_u = 0.00425603$

ϕ_{ue} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00299199

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14342573$$

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

--->

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

--->

$$s_u(4.9) = 0.24243176$$

$$M_u = M_{Rc}(4.14) = 1.1226E+008$$

$$u = s_u(4.1) = 0.00020406$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u1} -

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

$$u = 0.00020406$$

$$M_u = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00425603$$

$$\phi_{we}(5.4c) = 0.00035724$$

$$\phi_{ase}((5.4d), TBDY) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\phi_{psh, min} = \text{Min}(\phi_{psh, x}, \phi_{psh, y}) = 0.001496$$

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

$$\phi_{psh, x}(5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{psh, y}(5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

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

Calculation of μ_{2+}

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

$$\mu = 0.00020406$$

$$\mu_u = 1.1226 \times 10^{-8}$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$\mu_{ue} (5.4c) = 0.00035724$$

$$\mu_{ase} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1,nominal} = 0.08$$

For calculation of $s_{u1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_s/1.2$, 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$


```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of $cu^* = shear_factor * Max(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$

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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$

$y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 112732.921$

Calculation of Shear Strength at edge 1, $V_{r1} = 112732.921$

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

$V_{Co10} = 112732.921$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

s = 210.00
Vs is multiplied by Col = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 112732.921
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 112732.921
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.3332753E-012
Vu = 7.2890426E-033
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs is multiplied by Col = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

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

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

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.0640763E-031$
EDGE -B-
Shear Force, $V_b = -1.0640763E-031$
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, $V_e/V_r = 0.76584669$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.8226E+008$
 $\mu_{u1+} = 2.8226E+008$, 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
 $\mu_{u1-} = 2.8226E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.8226E+008$
 $\mu_{u2+} = 2.8226E+008$, 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
 $\mu_{u2-} = 2.8226E+008$, 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:
 $\mu_u = 8.2672130E-005$
 $\mu_u = 2.8226E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $c_o(5A.5, \text{TB DY}) = 0.002$
Final value of c_u : $c_u^* = \text{shear_factor} * \max(c_u, c_c) = 0.00425603$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TB DY: $c_u = 0.00425603$
 $w_e(5.4c) = 0.00035724$
 $a_{se}((5.4d), \text{TB DY}) = 0.02865579$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$

psh,min = Min(psh,x , psh,y) = 0.001496
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.001496
 Ash = Astir*ns = 78.53982
 No stirups, ns = 2.00
 bk = 500.00

psh,y (5.4d) = 0.00299199
 Ash = Astir*ns = 78.53982
 No stirups, ns = 2.00
 bk = 250.00

s = 210.00
 fywe = 555.55
 fce = 20.00
 From ((5.A5), TBDY), TBDY: cc = 0.002
 c = confinement factor = 1.00
 y1 = 0.00231479
 sh1 = 0.008
 ft1 = 666.66
 fy1 = 555.55
 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, ASCE 41-17.
 with fs1 = fs = 555.55
 with Es1 = Es = 200000.00
 y2 = 0.00231479
 sh2 = 0.008
 ft2 = 666.66
 fy2 = 555.55
 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, ASCE 41-17.
 with fs2 = fs = 555.55
 with Es2 = Es = 200000.00
 yv = 0.00231479
 shv = 0.008
 ftv = 666.66
 fyv = 555.55
 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, ASCE 41-17.
 with fsv = fs = 555.55

with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20164653$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20164653$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09776801$
and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.28396544$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.28396544$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.13768021$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.15301708$
 $Mu = MR_c (4.14) = 2.8226E+008$
 $u = su (4.1) = 8.2672130E-005$

Calculation of ratio l_b/d

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

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.2672130E-005$
 $Mu = 2.8226E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00425603$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00425603$
 $w_e (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $A_{sh} = A_{stir}*ns = 78.53982$
No stirups, $ns = 2.00$
 $bk = 250.00$

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544

```


$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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

--->

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

--->

$$s_u(4.9) = 0.15301708$$

$$M_u = M_{Rc}(4.14) = 2.8226E+008$$

$$u = s_u(4.1) = 8.2672130E-005$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2+}

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

$$u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$\phi_0(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00425603$$

$$w_e(5.4c) = 0.00035724$$

$$a_{se}((5.4d), \text{TBDY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\phi_{sh, min} = \text{Min}(\phi_{sh, x}, \phi_{sh, y}) = 0.001496$$

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

$$\phi_{sh, x}(5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{sh, y}(5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

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

Calculation of μ_2 -

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

$$\mu = 8.2672130E-005$$

$$\mu_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$\nu = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$\mu_{ue} (5.4c) = 0.00035724$$

$$\mu_{ase} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = knl*VColO

VColO = 245709.058

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 1.00$

$s/d = 0.525$

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

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

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 245709.058$

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

$V_{\text{ColO}} = 245709.058$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 1.00$

$s/d = 0.525$

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

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

$b_w = 250.00$

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

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

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 75969.712$
 Shear Force, $V_2 = 3075.705$
 Shear Force, $V_3 = -2.0575461E-014$
 Axial Force, $F = -4808.847$
 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, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.00435547$
 $u = y + p = 0.00435547$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00105989$ ((4.29), Biskinis Phd))
 $M_y = 1.7405E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4808.847$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.9053083E-006$
 with $f_y = 444.44$
 $d = 457.00$
 $y = 0.29581971$
 $A = 0.01813308$
 $B = 0.00996253$
 with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4808.847$
 $b = 250.00$

" = 0.0940919
y_comp = 1.2695706E-005
with fc = 20.00
Ec = 21019.039
y = 0.29520017
A = 0.0179155
B = 0.00986782
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.00329557

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio VyE/VCol0E = 0.76584669

d = 457.00

s = 0.00

t = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.00299199

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

bw = 250.00

The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution

where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

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

NUD = 4808.847

Ag = 125000.00

fcE = 20.00

fytE = fytE = 444.44

pl = Area_Tot_Long_Rein/(b*d) = 0.01803838

b = 250.00

d = 457.00

fcE = 20.00

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

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

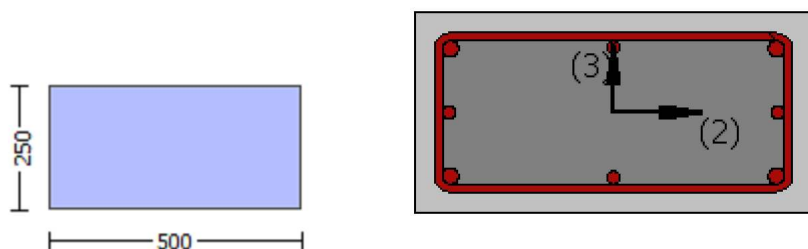
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

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

Shear Force, $V_a = -4692.913$
 EDGE -B-
 Bending Moment, $M_b = 115914.631$
 Shear Force, $V_b = 4692.913$
 BOTH EDGES
 Axial Force, $F = -4883.466$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 1231.504$
 -Compression: $A_{sc} = 829.3805$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 829.3805$
 -Compression: $A_{sc,com} = 829.3805$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 170165.705$
 $V_n ((10.3), ASCE 41-17) = k_n I^* V_{CoI0} = 170165.705$
 $V_{CoI} = 170165.705$
 $k_n I = 1.00$
 $displacement_ductility_demand = 0.02286035$

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)
 $f_c' = 16.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1.4198E+007$
 $V_u = 4692.913$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4883.466$
 $A_g = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 119679.72$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.525$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 0.00024437$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01068981$ ((4.29), Biskinis Phd))
 $M_y = 1.7406E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3025.481
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.6421E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c \cdot I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 6.9055145\text{E-}006$
with $f_y = 444.44$
 $d = 457.00$
 $y = 0.29584073$
 $A = 0.01813455$
 $B = 0.009964$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4883.466$
 $b = 250.00$
 $" = 0.0940919$
 $y_{\text{comp}} = 1.2695211\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.29521167$
 $A = 0.0179136$
 $B = 0.00986782$
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. 10

column C1, Floor 1

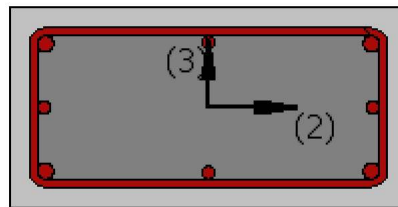
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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 , $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$ with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.1226\text{E}+008$

$\mu_{u1+} = 1.1226\text{E}+008$, 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

$\mu_{u1-} = 1.1226\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.1226\text{E}+008$

$\mu_{u2+} = 1.1226\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 1.1226\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

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

$\mu_u = 0.00020406$

$\mu_u = 1.1226\text{E}+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

α_c (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha_c) = 0.00425603$

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

From (5.4b), TBDY: $\mu_u = 0.00425603$

w_e (5.4c) = 0.00035724

a_{se} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$

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

 $p_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$p_{sh,y}$ (5.4d) = 0.00299199

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 210.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

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

c = confinement factor = 1.00

$y_1 = 0.00231479$

$sh_1 = 0.008$

$ft_1 = 666.66$

$fy_1 = 555.55$

$su_1 = 0.032$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266

```

and confined core properties:

```

b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573

```

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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

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:

$$\mu_u = 0.00020406$$

$$\mu_u = 1.1226 \times 10^{-8}$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear_factor} * \text{Max}(\mu_{cu}, \mu_{co}) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_{cu} = 0.00425603$$

$$\mu_{we} (5.4c) = 0.00035724$$

$$\mu_{ase} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.001496$$

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

$$\mu_{psh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{psh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{cc} = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

$$su_1 = 0.4 * \mu_{su1,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \mu_{su1,nominal} = 0.08$$

For calculation of $\mu_{su1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$


```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00

```

$h_o = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 555.55$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.22259049$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.22259049$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.10792266$

and confined core properties:

$b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.29581556$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.29581556$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su (4.9) = 0.24243176$
 $Mu = MRc (4.14) = 1.1226E+008$
 $u = su (4.1) = 0.00020406$

Calculation of ratio lb/d

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 112732.921$

Calculation of Shear Strength at edge 1, $Vr1 = 112732.921$

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

$VCol0 = 112732.921$

$knl = 1$ (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)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/d = 2.00$
 $Mu = 1.3332753E-012$
 $Vu = 7.2890426E-033$
 $d = 0.8 \cdot h = 200.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $Vs = 0.00$
 $Av = 157079.633$
 $fy = 444.44$
 $s = 210.00$
 Vs is multiplied by $Col = 0.00$
 $s/d = 1.05$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 297085.704$
 $bw = 500.00$

Calculation of Shear Strength at edge 2, $Vr2 = 112732.921$

$Vr2 = VCol ((10.3), ASCE 41-17) = knl \cdot VCol0$

$VCol0 = 112732.921$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.0640763E-031$

EDGE -B-

Shear Force, $V_b = -1.0640763E-031$

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, $V_e/V_r = 0.76584669$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.8226E+008$

$Mu_{1+} = 2.8226E+008$, 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

$Mu_{1-} = 2.8226E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.8226E+008$

$Mu_{2+} = 2.8226E+008$, 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

$Mu_{2-} = 2.8226E+008$, 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 Mu_{1+}

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

$\phi_u = 8.2672130E-005$

$M_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

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

From (5.4b), TBDY: $\phi_u = 0.00425603$

ϕ_{we} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00299199

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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

--->

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

--->

$$s_u(4.9) = 0.15301708$$

$$M_u = M_{Rc}(4.14) = 2.8226E+008$$

$$u = s_u(4.1) = 8.2672130E-005$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u1} -

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

$$u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00425603$$

$$\phi_{we}(5.4c) = 0.00035724$$

$$\phi_{ase}((5.4d), \text{TBDY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{psh, min} = \text{Min}(\phi_{psh, x}, \phi_{psh, y}) = 0.001496$$

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

$$\phi_{psh, x}(5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{psh, y}(5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

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

Calculation of μ_{2+}

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

$$\mu = 8.2672130E-005$$

$$\mu_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$w_e (5.4c) = 0.00035724$$

$$a_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1,nominal} = 0.08$$

For calculation of $s_{u1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_s/1.2$, 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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/lbu,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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Aslten/(b*d)*(fs1/fc) = 0.20164653
2 = Aslcom/(b*d)*(fs2/fc) = 0.20164653
v = Aslmid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Aslten/(b*d)*(fs1/fc) = 0.28396544
2 = Aslcom/(b*d)*(fs2/fc) = 0.28396544
v = Aslmid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-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 = 8.2672130E-005

Mu = 2.8226E+008

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
    2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
    v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
    2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
    v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

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

$V_{Co10} = 245709.058$

$knl = 1$ (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)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

s = 210.00
Vs is multiplied by Col = 1.00
s/d = 0.525
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 245709.058
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 245709.058
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0649661E-012
Vu = 1.0640763E-031
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 132976.137
Av = 157079.633
fy = 444.44
s = 210.00
Vs is multiplied by Col = 1.00
s/d = 0.525
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

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

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

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($lb/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -5.9662941\text{E-}011$

Shear Force, $V2 = -4692.913$

Shear Force, $V3 = 3.1394051\text{E-}014$

Axial Force, $F = -4883.466$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $Asl_t = 1231.504$

-Compression: $Asl_c = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten} = 829.3805$

-Compression: $Asl_{com} = 829.3805$

-Middle: $Asl_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \quad * \quad u = 0.03298859$

$u = y + p = 0.03298859$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00945001$ ((4.29), Biskinis Phd))

$My = 7.7590\text{E+}007$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 4.1053\text{E+}012$

factor = 0.30

$Ag = 125000.00$

$fc' = 20.00$

$N = 4883.466$

$Ec * Ig = 1.3684\text{E+}013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 1.5936328\text{E-}005$

with $fy = 444.44$

$d = 207.00$

$y = 0.32636518$

$A = 0.02001809$

$B = 0.01213028$

with $pt = 0.00801334$

$pc = 0.00801334$

$pv = 0.00388525$

$N = 4883.466$

$b = 500.00$

$" = 0.20772947$

$y_{comp} = 2.5390422\text{E-}005$

with $fc = 20.00$

$Ec = 21019.039$

$y = 0.32587375$

$A = 0.01977419$

$B = 0.01202411$

with $Es = 200000.00$

Calculation of ratio lb/d

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

- Calculation of p -

From table 10-8: $p = 0.02353857$

with:

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

shear control ratio $V_{yE}/V_{ColOE} = 0.66388728$

$d = 207.00$

$s = 0.00$

$t = A_v/(b_w \cdot s) + 2 \cdot t_f/b_w \cdot (f_{fe}/f_s) = 0.001496$

$A_v = 157.0796$, 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.

$N_{UD} = 4883.466$

$A_g = 125000.00$

$f_{cE} = 20.00$

$f_{yE} = f_{yI} = 444.44$

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

$b = 500.00$

$d = 207.00$

$f_{cE} = 20.00$

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

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

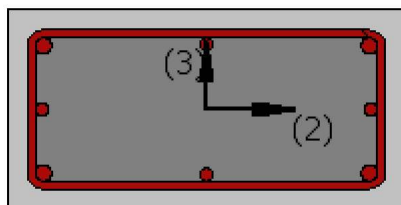
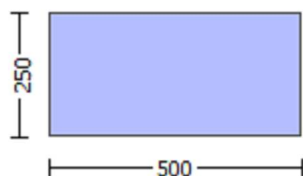
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity 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, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -5.9662941E-011$

Shear Force, $V_a = 3.1394051E-014$

EDGE -B-

Bending Moment, $M_b = -3.4535259E-011$

Shear Force, $V_b = -3.1394051E-014$

BOTH EDGES

Axial Force, $F = -4883.466$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1231.504$

-Compression: $As_c = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = V_n = 100971.97$
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col0} = 100971.97$
 $V_{Col} = 100971.97$
 $knl = 1.00$
 $displacement_ductility_demand = 0.00$

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

$\lambda = 1$ (normal-weight concrete)
 $f'_c = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 5.9662941E-011$
 $V_u = 3.1394051E-014$
 $d = 0.8 * h = 200.00$
 $N_u = 4883.466$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 0.00$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 1.05$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $bw = 500.00$

$displacement_ductility_demand$ is calculated as γ / y

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

From analysis, chord rotation $\theta = 1.0734668E-021$
 $\gamma = (M_y * L_s / 3) / E_{eff} = 0.00945001$ ((4.29), Biskinis Phd))
 $M_y = 7.7590E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f'_c = 20.00$
 $N = 4883.466$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \min(\gamma_{ten}, \gamma_{com})$
 $\gamma_{ten} = 1.5936328E-005$
with $f_y = 444.44$
 $d = 207.00$
 $\gamma = 0.32636518$
 $A = 0.02001809$
 $B = 0.01213028$
with $pt = 0.00801334$
 $pc = 0.00801334$
 $pv = 0.00388525$
 $N = 4883.466$

b = 500.00
" = 0.20772947
y_comp = 2.5390422E-005
with fc = 20.00
Ec = 21019.039
y = 0.32587375
A = 0.01977419
B = 0.01202411
with Es = 200000.00

Calculation of ratio l_b/l_d

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

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

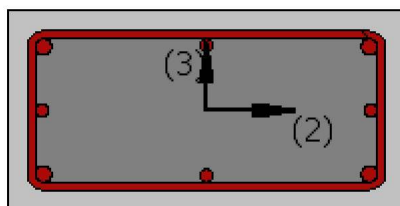
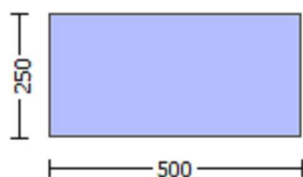
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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, $\phi = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

BOTH EDGES

Axial Force, $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 829.3805$

-Compression: $A_{st, \text{com}} = 829.3805$

-Middle: $A_{st, \text{mid}} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.1226E+008$

$M_{u1+} = 1.1226E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.1226E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.1226E+008$

$M_{u2+} = 1.1226E+008$, 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

$M_{u2-} = 1.1226E+008$, 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:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \alpha_c = 0.00425603$$

$$\alpha_w (5.4c) = 0.00035724$$

$$\alpha_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\rho_{sh, \min} = \text{Min}(\rho_{sh, x}, \rho_{sh, y}) = 0.001496$$

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

$$\rho_{sh, x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\rho_{sh, y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

For calculation of $\alpha_{su1_nominal}$ 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

For calculation of $\alpha_{su2_nominal}$ 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, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 555.55$$

```

with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724

```

$ase((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression $((5.4d), TBDY)$ for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x(5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y(5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From $((5.A5), TBDY)$, $TBDY$: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\epsilon_{sv_nominal}$ and γ_v , ϕ_{sv} , ϕ_{ftv} , ϕ_{fyv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , $\phi_{1,ft1}$, ϕ_{fy1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 555.55$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22259049$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22259049$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10792266$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

c_c (5A.5, TBDY) = 0.002

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.29581556$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.29581556$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

ϕ_u (4.9) = 0.24243176

$\mu_u = M_{Rc}$ (4.14) = 1.1226E+008

$u = \phi_u$ (4.1) = 0.00020406

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2+}

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

$u = 0.00020406$

$\mu_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

c_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, c_c) = 0.00425603$

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

From (5.4b), TBDY: $\phi_u = 0.00425603$

ϕ_{ue} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00231479
sh1 = 0.008

ft1 = 666.66

fy1 = 555.55

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, ASCE 41-17.

with fs1 = fs = 555.55

with Es1 = Es = 200000.00

y2 = 0.00231479

sh2 = 0.008

ft2 = 666.66

fy2 = 555.55

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, ASCE 41-17.

with fs2 = fs = 555.55

with Es2 = Es = 200000.00

yv = 0.00231479

shv = 0.008

ftv = 666.66

fyv = 555.55

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, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049

2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049

v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00


```

cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.001496

```

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

```

psh,x (5.4d) = 0.001496
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00

```

```

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

```

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66

```

```

fy1 = 555.55
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, ASCE 41-17.
    with fs1 = fs = 555.55
    with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
    with fs2 = fs = 555.55
    with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 112732.921$

Calculation of Shear Strength at edge 1, $V_{r1} = 112732.921$

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

$V_{Col0} = 112732.921$

$k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $Col = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 112732.921$

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

$V_{Col0} = 112732.921$

$k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $Col = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.0640763E-031$

EDGE -B-

Shear Force, $V_b = -1.0640763E-031$

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, $V_e/V_r = 0.76584669$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.8226E+008$

$M_{u1+} = 2.8226E+008$, 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

$M_{u1-} = 2.8226E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.8226E+008$

Mu2+ = 2.8226E+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

Mu2- = 2.8226E+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 Mu1+

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

$$\phi_u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$\nu = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.00425603$$

$$\phi_{we} (5.4c) = 0.00035724$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$$

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

$$\phi_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_{cc} = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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 , ft_1 , fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

```

ft2 = 666.66
fy2 = 555.55
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/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = fs = 555.55
    with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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/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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu1-

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

u = 8.2672130E-005
Mu = 2.8226E+008

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00425603$$

$$\phi_w (5.4c) = 0.00035724$$

$$\phi_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$$

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

$$\phi_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\phi_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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, ASCE 41-17.

$$\text{with } f_{s2} = f_s = 555.55$$

```

with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-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 = 8.2672130E-005
Mu = 2.8226E+008

```

with full section properties:

```

b = 250.00
d = 457.00
d' = 43.00
v = 0.00204242
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724

```


$ase((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression $((5.4d), TBDY)$ for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x(5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y(5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From $((5.A5), TBDY)$, $TBDY$: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $\text{Min}(1, 1.25*(lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\epsilon_{suv_nominal}$ and γ_v , Δv , Δh_v , Δf_v , Δf_{yv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , Δh_1 , Δf_1 , Δf_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = f_s = 555.55$
with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.20164653$
2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.20164653$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.09776801$

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.28396544$
2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.28396544$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.13768021$

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

--->

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

--->

$\mu_u \text{ (4.9)} = 0.15301708$
 $\mu_u = M_{Rc} \text{ (4.14)} = 2.8226E+008$
 $u = \mu_u \text{ (4.1)} = 8.2672130E-005$

Calculation of ratio l_b/l_d

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

Calculation of μ_u -

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

$u = 8.2672130E-005$
 $\mu_u = 2.8226E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00425603$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00425603$
 $\mu_u \text{ (5.4c)} = 0.00035724$
 $\mu_u \text{ (5.4d), TBDY} = 0.02865579$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$
Expression ((5.4d), TBDY) for $\mu_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\mu_{sh,x} \text{ (5.4d)} = 0.001496$
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$
No stirrups, $n_s = 2.00$
 $b_k = 500.00$

psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 210.00
fywe = 555.55
fce = 20.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00231479
sh1 = 0.008

ft1 = 666.66

fy1 = 555.55

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, ASCE 41-17.

with fs1 = fs = 555.55

with Es1 = Es = 200000.00

y2 = 0.00231479

sh2 = 0.008

ft2 = 666.66

fy2 = 555.55

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, ASCE 41-17.

with fs2 = fs = 555.55

with Es2 = Es = 200000.00

yv = 0.00231479

shv = 0.008

ftv = 666.66

fyv = 555.55

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, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653

2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653

v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 20.00

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.28396544$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.28396544$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.13768021$$

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

--->

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

--->

$$su(4.9) = 0.15301708$$

$$Mu = MRc(4.14) = 2.8226E+008$$

$$u = su(4.1) = 8.2672130E-005$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

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

$$V_{Col0} = 245709.058$$

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

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

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

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

$$M/Vd = 2.00$$

$$Mu = 2.0649661E-012$$

$$Vu = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 132976.137$$

$$A_v = 157079.633$$

$$f_y = 444.44$$

$$s = 210.00$$

$$V_s \text{ is multiplied by } Col = 1.00$$

$$s/d = 0.525$$

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

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

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 245709.058$

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

$$V_{Col0} = 245709.058$$

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

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

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

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

$$M/Vd = 2.00$$

$$Mu = 2.0649661E-012$$

$$Vu = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$
 $A_v = 157079.633$
 $f_y = 444.44$
 $s = 210.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.525$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $b_w = 250.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{sm} = 444.44$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Section Height, $H = 250.00$
Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.4198E+007$
Shear Force, $V_2 = -4692.913$
Shear Force, $V_3 = 3.1394051E-014$
Axial Force, $F = -4883.466$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1231.504$
-Compression: $As_c = 829.3805$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 829.3805$
-Compression: $As_{c,com} = 829.3805$
-Middle: $As_{l,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \phi \cdot u = 0.04202682$
 $u = y + p = 0.04202682$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01068981$ ((4.29), Biskinis Phd))
 $M_y = 1.7406E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3025.481
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.9055145E-006$
with $f_y = 444.44$
 $d = 457.00$
 $y = 0.29584073$
 $A = 0.01813455$
 $B = 0.009964$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4883.466$
 $b = 250.00$
 $" = 0.0940919$
 $y_{comp} = 1.2695211E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.29521167$
 $A = 0.0179136$
 $B = 0.00986782$
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: $p = 0.03133702$

with:

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

shear control ratio $V_y E / V_{col} E = 0.76584669$

$d = 457.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00299199$

$A_v = 157.0796$, 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.

$N_{UD} = 4883.466$

$A_g = 125000.00$

$f_c E = 20.00$

$f_y E = f_y = 444.44$

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

$b = 250.00$

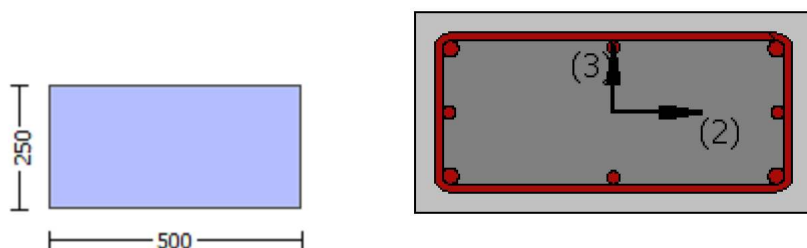
$d = 457.00$

$f_c E = 20.00$

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

Calculation No. 13

column C1, Floor 1
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity 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, $\gamma = 1.00$
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of γ for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material: Steel Strength, $f_s = f_{sm} = 444.44$

#####

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.4198E+007$
Shear Force, $V_a = -4692.913$
EDGE -B-
Bending Moment, $M_b = 115914.631$
Shear Force, $V_b = 4692.913$
BOTH EDGES
Axial Force, $F = -4883.466$
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, $Db_{L,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 220651.69$
 V_n ((10.3), ASCE 41-17) = $k_n \phi V_{CoI} = 220651.69$
 $V_{CoI} = 220651.69$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.12414702$

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

= 1 (normal-weight concrete)
 $f'_c = 16.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 115914.631$
 $V_u = 4692.913$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4883.466$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 119679.72$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $CoI = 1.00$
 $s/d = 0.525$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 250.00$

 $displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 0.00013159$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00105998$ ((4.29), Biskinis Phd))
 $M_y = 1.7406E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
factor = 0.30
Ag = 125000.00
fc' = 20.00
N = 4883.466
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 6.9055145E-006$
with $f_y = 444.44$
d = 457.00
 $y = 0.29584073$
A = 0.01813455
B = 0.009964
with $p_t = 0.00725935$
pc = 0.00725935
pv = 0.00351968
N = 4883.466
b = 250.00
" = 0.0940919
 $\phi_{y_comp} = 1.2695211E-005$
with $f_c = 20.00$
Ec = 21019.039
 $y = 0.29521167$
A = 0.0179136
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

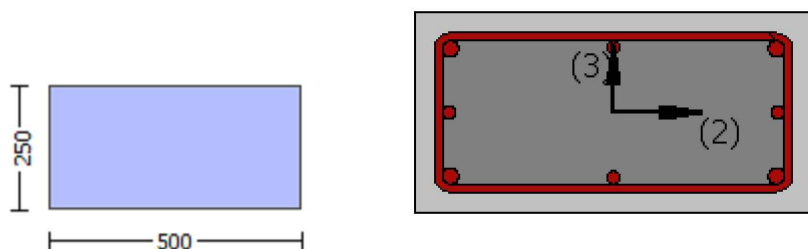
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_u)

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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, $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$

with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.1226E+008$

$\mu_{u1+} = 1.1226E+008$, 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

$\mu_{u1-} = 1.1226E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.1226E+008$

$\mu_{u2+} = 1.1226E+008$, 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

$\mu_{u2-} = 1.1226E+008$, 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:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

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

From (5.4b), TBDY: $\phi_u = 0.00425603$

ϕ_{ue} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00299199

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556

```

$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14342573$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)

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

--->
 $\mu_u (4.9) = 0.24243176$
 $\mu_u = M_{Rc} (4.14) = 1.1226E+008$
 $u = \mu_u (4.1) = 0.00020406$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u1} -

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

$u = 0.00020406$
 $\mu_u = 1.1226E+008$

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $f_c = 20.00$
 $\alpha (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.00425603$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00425603$
 $\mu_w (5.4c) = 0.00035724$
 $\mu_{ase} ((5.4d), TBDY) = 0.02865579$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$
 $\mu_{sh, min} = \text{Min}(\mu_{sh, x}, \mu_{sh, y}) = 0.001496$
Expression ((5.4d), TBDY) for $\mu_{sh, min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\mu_{sh, x} (5.4d) = 0.001496$
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$
No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\mu_{sh, y} (5.4d) = 0.00299199$
 $A_{sh} = A_{stir} \cdot n_s = 78.53982$
No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$
From ((5.A5), TBDY), TBDY: $\mu_c = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00231479$
 $sh_1 = 0.008$
 $f_{t1} = 666.66$
 $f_{y1} = 555.55$
 $\mu_{u1} = 0.032$
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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

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

Calculation of μ_{2+}

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

$$\mu = 0.00020406$$

$$\mu_u = 1.1226 \times 10^{-8}$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_c: \mu_c^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_c) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_c = 0.00425603$$

$$\mu_w (5.4c) = 0.00035724$$

$$\mu_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 112732.921$

Calculation of Shear Strength at edge 1, $V_{r1} = 112732.921$

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

$V_{Co10} = 112732.921$

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

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

= 1 (normal-weight concrete)

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

$M / V_d = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

s = 210.00
Vs is multiplied by Col = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

Calculation of Shear Strength at edge 2, Vr2 = 112732.921
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 112732.921
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.3332753E-012
Vu = 7.2890426E-033
d = 0.8*h = 200.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 0.00
Av = 157079.633
fy = 444.44
s = 210.00
Vs is multiplied by Col = 0.00
s/d = 1.05
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 500.00

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

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

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55

Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars

Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 1.0640763E-031$
EDGE -B-
Shear Force, $V_b = -1.0640763E-031$
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, $V_e/V_r = 0.76584669$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 2.8226E+008$
 $\mu_{u1+} = 2.8226E+008$, 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
 $\mu_{u1-} = 2.8226E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 2.8226E+008$
 $\mu_{u2+} = 2.8226E+008$, 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
 $\mu_{u2-} = 2.8226E+008$, 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:
 $\mu_u = 8.2672130E-005$
 $\mu_u = 2.8226E+008$

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $f_c = 20.00$
 $c_o(5A.5, \text{TB DY}) = 0.002$
Final value of c_u : $c_u^* = \text{shear_factor} * \max(c_u, c_c) = 0.00425603$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TB DY: $c_u = 0.00425603$
 $w_e(5.4c) = 0.00035724$
 $a_{se}((5.4d), \text{TB DY}) = 0.02865579$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_{i2} = 459400.00$

psh,min = Min(psh,x , psh,y) = 0.001496
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x (5.4d) = 0.001496
 Ash = Astir*ns = 78.53982
 No stirups, ns = 2.00
 bk = 500.00

psh,y (5.4d) = 0.00299199
 Ash = Astir*ns = 78.53982
 No stirups, ns = 2.00
 bk = 250.00

s = 210.00
 fywe = 555.55
 fce = 20.00
 From ((5.A5), TBDY), TBDY: cc = 0.002
 c = confinement factor = 1.00
 y1 = 0.00231479
 sh1 = 0.008
 ft1 = 666.66
 fy1 = 555.55
 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, ASCE 41-17.
 with fs1 = fs = 555.55
 with Es1 = Es = 200000.00
 y2 = 0.00231479
 sh2 = 0.008
 ft2 = 666.66
 fy2 = 555.55
 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, ASCE 41-17.
 with fs2 = fs = 555.55
 with Es2 = Es = 200000.00
 yv = 0.00231479
 shv = 0.008
 ftv = 666.66
 fyv = 555.55
 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, ASCE 41-17.
 with fsv = fs = 555.55

```

with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005
-----

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

Calculation of Mu1-
-----
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 8.2672130E-005
Mu = 2.8226E+008
-----

with full section properties:
b = 250.00
d = 457.00
d' = 43.00
v = 0.00204242
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00
ho = 190.00
bi2 = 459400.00
psh,min = Min(psh,x , psh,y) = 0.001496
Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without
earthquake detailing (90° closed stirrups)
-----
psh,x (5.4d) = 0.001496
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 500.00
-----
psh,y (5.4d) = 0.00299199
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

```

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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

--->

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

--->

$$s_u(4.9) = 0.15301708$$

$$M_u = M_{Rc}(4.14) = 2.8226E+008$$

$$u = s_u(4.1) = 8.2672130E-005$$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2+}

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

$$u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00425603$$

$$w_e(5.4c) = 0.00035724$$

$$a_{se}((5.4d), TBDY) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.001496$$

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

$$p_{sh, x}(5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

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

Calculation of μ_2 -

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

$$\mu = 8.2672130E-005$$

$$\mu_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$\nu = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$\mu_{ue} (5.4c) = 0.00035724$$

$$\mu_{ase} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1,nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } s_{u1,nominal} = 0.08$$

For calculation of $s_{u1,nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_s/1.2$, 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 245709.058

Calculation of Shear Strength at edge 1, Vr1 = 245709.058

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

VColO = 245709.058

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*VF'

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 1.00$

$s/d = 0.525$

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

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

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 245709.058$

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

$V_{\text{Col}} = 245709.058$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 1.00$

$s/d = 0.525$

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

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

$b_w = 250.00$

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

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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 Section Height, $H = 250.00$
 Section Width, $W = 500.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -3.4535259E-011$
 Shear Force, $V_2 = 4692.913$
 Shear Force, $V_3 = -3.1394051E-014$
 Axial Force, $F = -4883.466$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 829.3805$
 -Compression: $A_{st,com} = 829.3805$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.03298859$
 $u = y + p = 0.03298859$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00945001$ ((4.29), Biskinis Phd))
 $M_y = 7.7590E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.1053E+012$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c * I_g = 1.3684E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.5936328E-005$
 with $f_y = 444.44$
 $d = 207.00$
 $y = 0.32636518$
 $A = 0.02001809$
 $B = 0.01213028$
 with $pt = 0.00801334$
 $pc = 0.00801334$
 $pv = 0.00388525$
 $N = 4883.466$
 $b = 500.00$

" = 0.20772947
y_comp = 2.5390422E-005
with fc = 20.00
Ec = 21019.039
y = 0.32587375
A = 0.01977419
B = 0.01202411
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.02353857

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio VyE/VColOE = 0.66388728

d = 207.00

s = 0.00

t = Av/(bw*s) + 2*tf/bw*(ffe/fs) = 0.001496

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

bw = 500.00

The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution

where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

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

NUD = 4883.466

Ag = 125000.00

fcE = 20.00

fytE = fytE = 444.44

pl = Area_Tot_Long_Rein/(b*d) = 0.01991193

b = 500.00

d = 207.00

fcE = 20.00

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

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

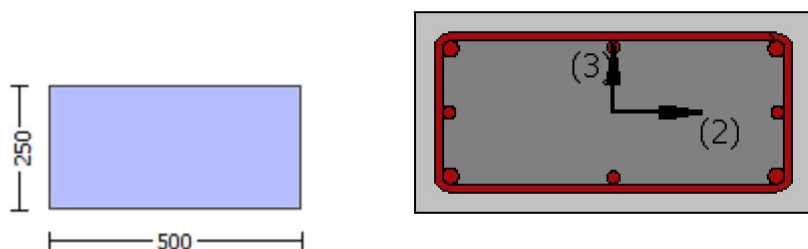
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Existing material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -5.9662941E-011$

Shear Force, $V_a = 3.1394051\text{E-}014$
 EDGE -B-
 Bending Moment, $M_b = -3.4535259\text{E-}011$
 Shear Force, $V_b = -3.1394051\text{E-}014$
 BOTH EDGES
 Axial Force, $F = -4883.466$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 829.3805$
 -Compression: $A_{sc,com} = 829.3805$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 100971.97$
 V_n ((10.3), ASCE 41-17) = $k_n I V_{CoI} = 100971.97$
 $V_{CoI} = 100971.97$
 $k_n = 1.00$
 $\text{displacement_ductility_demand} = 0.00$

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)
 $f'_c = 16.00$, but $f'_c^{0.5} \leq 8.3$ MPa ((22.5.3.1, ACI 318-14))
 $M/Vd = 2.00$
 $M_u = 3.4535259\text{E-}011$
 $V_u = 3.1394051\text{E-}014$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4883.466$
 $A_g = 125000.00$
 From ((11.5.4.8), ACI 318-14: $V_s = 0.00$
 $A_v = 157079.633$
 $f_y = 400.00$
 $s = 210.00$
 V_s is multiplied by $Col = 0.00$
 $s/d = 1.05$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From ((11-11), ACI 440: $V_s + V_f \leq 265721.532$
 $b_w = 500.00$

$\text{displacement_ductility_demand}$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 4.7176720\text{E-}022$
 $y = (M_y L_s / 3) / E_{eff} = 0.00945001$ ((4.29), Biskinis Phd))
 $M_y = 7.7590\text{E+}007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053\text{E+}012$
 $\text{factor} = 0.30$
 $A_g = 125000.00$
 $f'_c = 20.00$
 $N = 4883.466$
 $E_c \cdot I_g = 1.3684\text{E+}013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.5936328\text{E-}005$
with $f_y = 444.44$
 $d = 207.00$
 $y = 0.32636518$
 $A = 0.02001809$
 $B = 0.01213028$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4883.466$
 $b = 500.00$
 $" = 0.20772947$
 $y_{\text{comp}} = 2.5390422\text{E-}005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $y = 0.32587375$
 $A = 0.01977419$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio 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. 16

column C1, Floor 1

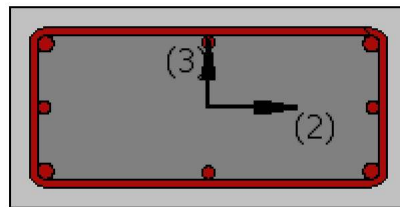
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ_r)

Edge: End

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -7.2890426E-033$

EDGE -B-

Shear Force, $V_b = 7.2890426E-033$

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 , $V_e/V_r = 0.66388728$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 74841.953$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.1226\text{E}+008$

$\mu_{u1+} = 1.1226\text{E}+008$, 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

$\mu_{u1-} = 1.1226\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.1226\text{E}+008$

$\mu_{u2+} = 1.1226\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 1.1226\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

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

$\mu_u = 0.00020406$

$\mu_u = 1.1226\text{E}+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00425603$

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

From (5.4b), TBDY: $\mu_u = 0.00425603$

we (5.4c) = 0.00035724

ase ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$

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

 $\mu_{sh,x} (5.4d) = 0.001496$

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\mu_{sh,y} (5.4d) = 0.00299199$

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

$s = 210.00$

$f_{ywe} = 555.55$

$f_{ce} = 20.00$

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

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

$y_1 = 0.00231479$

$sh_1 = 0.008$

$ft_1 = 666.66$

$fy_1 = 555.55$

$su_1 = 0.032$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

Calculation of ratio lb/ld

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

Calculation of μ_1 -

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

$$\mu = 0.00020406$$

$$\mu_u = 1.1226 \times 10^{-8}$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha_c) = 0.00425603$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00425603$$

$$w_e (5.4c) = 0.00035724$$

$$a_{se} ((5.4d), \text{TB DY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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

$$p_{sh,x} (5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

```

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/lbu,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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

with full section properties:

$b = 500.00$
 $d = 207.00$
 $d' = 43.00$
 $v = 0.00225456$
 $N = 4666.932$
 $f_c = 20.00$
 $\phi_c (5A.5, \text{TB DY}) = 0.002$
 Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TB DY: $\phi_c = 0.00425603$
 $\phi_w (5.4c) = 0.00035724$
 $\phi_{se} ((5.4d), \text{TB DY}) = 0.02865579$
 $b_o = 440.00$
 $h_o = 190.00$
 $b_i^2 = 459400.00$
 $\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$
 Expression ((5.4d), TB DY) for $\phi_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{sh,x} (5.4d) = 0.001496$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 500.00$

$\phi_{sh,y} (5.4d) = 0.00299199$
 $A_{sh} = A_{stir} * n_s = 78.53982$
 No stirrups, $n_s = 2.00$
 $b_k = 250.00$

$s = 210.00$
 $f_{ywe} = 555.55$
 $f_{ce} = 20.00$

From ((5A5), TB DY), TB DY: $\phi_c = 0.002$
 $c = \text{confinement factor} = 1.00$

$y_1 = 0.00231479$
 $sh_1 = 0.008$
 $ft_1 = 666.66$
 $fy_1 = 555.55$
 $su_1 = 0.032$

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

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

$su_1 = 0.4 * esu1_nominal ((5.5), \text{TB DY}) = 0.032$

From table 5A.1, TB DY: $esu1_nominal = 0.08$,

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, TB DY.

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, ASCE 41-17.

with $fs_1 = fs = 555.55$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00231479$
 $sh_2 = 0.008$
 $ft_2 = 666.66$
 $fy_2 = 555.55$
 $su_2 = 0.032$

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

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

$su_2 = 0.4 * esu2_nominal ((5.5), \text{TB DY}) = 0.032$

From table 5A.1, TB DY: $esu2_nominal = 0.08$,

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, TB DY.

y_2 , sh_2 , ft_2 , fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = fs = 555.55$

with $Es_2 = Es = 200000.00$

$y_v = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.22259049
    2 = Asl,com/(b*d)*(fs2/fc) = 0.22259049
    v = Asl,mid/(b*d)*(fsv/fc) = 0.10792266
and confined core properties:
b = 440.00
d = 177.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556
    2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556
    v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573
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) = 0.24243176
Mu = MRc (4.14) = 1.1226E+008
u = su (4.1) = 0.00020406

```

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 = 0.00020406
Mu = 1.1226E+008

```

with full section properties:

```

b = 500.00
d = 207.00
d' = 43.00
v = 0.00225456
N = 4666.932
fc = 20.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00425603
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00425603
we (5.4c) = 0.00035724
ase ((5.4d), TBDY) = 0.02865579
bo = 440.00

```


$h_o = 190.00$
 $bi2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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 $fsy1 = fs/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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 $fsy2 = fs/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$
 $shv = 0.008$
 $ftv = 666.66$
 $fyv = 555.55$
 $suv = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = fs = 555.55$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.22259049$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.22259049$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.10792266$

and confined core properties:

$b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 20.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b \cdot d) \cdot (fs1/fc) = 0.29581556$
 $2 = Asl,com/(b \cdot d) \cdot (fs2/fc) = 0.29581556$
 $v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su (4.9) = 0.24243176$
 $Mu = MRc (4.14) = 1.1226E+008$
 $u = su (4.1) = 0.00020406$

Calculation of ratio lb/d

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 112732.921$

Calculation of Shear Strength at edge 1, $Vr1 = 112732.921$

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

$VCol0 = 112732.921$

$knl = 1$ (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)
 $fc' = 20.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 1.3332753E-012$
 $Vu = 7.2890426E-033$
 $d = 0.8 \cdot h = 200.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $Vs = 0.00$
 $Av = 157079.633$
 $fy = 444.44$
 $s = 210.00$
 Vs is multiplied by $Col = 0.00$
 $s/d = 1.05$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 297085.704$
 $bw = 500.00$

Calculation of Shear Strength at edge 2, $Vr2 = 112732.921$

$Vr2 = VCol ((10.3), ASCE 41-17) = knl \cdot VCol0$

$VCol0 = 112732.921$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 0.00$

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

V_s is multiplied by $\text{Col} = 0.00$

$s/d = 1.05$

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

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

$b_w = 500.00$

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

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

Constant Properties

Knowledge Factor, $\phi = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.55$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 1.0640763E-031$

EDGE -B-

Shear Force, $V_b = -1.0640763E-031$

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, $V_e/V_r = 0.76584669$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 188175.468$

with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.8226E+008$

$\mu_{u1+} = 2.8226E+008$, 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

$\mu_{u1-} = 2.8226E+008$, 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.8226E+008$

$\mu_{u2+} = 2.8226E+008$, 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

$\mu_{u2-} = 2.8226E+008$, 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:

$\phi_u = 8.2672130E-005$

$M_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

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

From (5.4b), TBDY: $\phi_u = 0.00425603$

ϕ_{ue} (5.4c) = 0.00035724

ϕ_{ase} ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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

$\phi_{sh,x}$ (5.4d) = 0.001496

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

No stirrups, $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$ (5.4d) = 0.00299199

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

No stirrups, $n_s = 2.00$

$b_k = 250.00$

```

s = 210.00
fywe = 555.55
fce = 20.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00231479
sh1 = 0.008
ft1 = 666.66
fy1 = 555.55
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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

--->

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

--->

$$s_u(4.9) = 0.15301708$$

$$M_u = M_{Rc}(4.14) = 2.8226E+008$$

$$u = s_u(4.1) = 8.2672130E-005$$

Calculation of ratio I_b/I_d

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

Calculation of M_{u1} -

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

$$u = 8.2672130E-005$$

$$M_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} \cdot \text{Max}(\alpha, \alpha_c) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \alpha = 0.00425603$$

$$w_e(5.4c) = 0.00035724$$

$$a_{se}((5.4d), \text{TBDY}) = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.001496$$

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

$$p_{sh, x}(5.4d) = 0.001496$$

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

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

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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
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, ASCE 41-17.
with fs1 = fs = 555.55
with Es1 = Es = 200000.00
y2 = 0.00231479
sh2 = 0.008
ft2 = 666.66
fy2 = 555.55
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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

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

Calculation of μ_{2+}

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

$$\mu = 8.2672130E-005$$

$$\mu_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.00425603$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00425603$$

$$w_e \text{ (5.4c)} = 0.00035724$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.001496$$

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

$$\mu_{sh,x} \text{ (5.4d)} = 0.001496$$

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

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

$$b_k = 500.00$$

$$\mu_{sh,y} \text{ (5.4d)} = 0.00299199$$

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1_nominal} \text{ ((5.5), TBDY)} = 0.032$$

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

For calculation of $s_{u1_nominal}$ and $y_1, sh_1, f_{t1}, f_{y1}$, it is considered characteristic value $f_{sy1} = f_s/1.2$, 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, ASCE 41-17.

$$\text{with } f_{s1} = f_s = 555.55$$

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$


```

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, ASCE 41-17.
with fs2 = fs = 555.55
with Es2 = Es = 200000.00
yv = 0.00231479
shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
with fsv = fs = 555.55
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-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 = 8.2672130E-005

Mu = 2.8226E+008

with full section properties:

$b = 250.00$
 $d = 457.00$
 $d' = 43.00$
 $v = 0.00204242$
 $N = 4666.932$
 $fc = 20.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00425603$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00425603$
 $we (5.4c) = 0.00035724$
 $ase ((5.4d), TBDY) = 0.02865579$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh,min = Min(psh,x, psh,y) = 0.001496$
 Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x (5.4d) = 0.001496$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 500.00$

$psh,y (5.4d) = 0.00299199$
 $Ash = Astir*ns = 78.53982$
 No stirrups, $ns = 2.00$
 $bk = 250.00$

$s = 210.00$
 $fywe = 555.55$
 $fce = 20.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.002$
 $c = confinement\ factor = 1.00$
 $y1 = 0.00231479$
 $sh1 = 0.008$
 $ft1 = 666.66$
 $fy1 = 555.55$
 $su1 = 0.032$
 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, ASCE 41-17.
 with $fs1 = fs = 555.55$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00231479$
 $sh2 = 0.008$
 $ft2 = 666.66$
 $fy2 = 555.55$
 $su2 = 0.032$
 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, ASCE 41-17.
 with $fs2 = fs = 555.55$
 with $Es2 = Es = 200000.00$
 $yv = 0.00231479$

```

shv = 0.008
ftv = 666.66
fyv = 555.55
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, ASCE 41-17.
    with fsv = fs = 555.55
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.20164653
    2 = Asl,com/(b*d)*(fs2/fc) = 0.20164653
    v = Asl,mid/(b*d)*(fsv/fc) = 0.09776801
and confined core properties:
b = 190.00
d = 427.00
d' = 13.00
fcc (5A.2, TBDY) = 20.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544
    2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544
    v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021
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) = 0.15301708
Mu = MRc (4.14) = 2.8226E+008
u = su (4.1) = 8.2672130E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 245709.058$

Calculation of Shear Strength at edge 1, $V_{r1} = 245709.058$

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

$V_{Co10} = 245709.058$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$V_u = 1.0640763E-031$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14: $V_s = 132976.137$

$A_v = 157079.633$

$f_y = 444.44$

s = 210.00
Vs is multiplied by Col = 1.00
s/d = 0.525
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 245709.058
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 245709.058
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 20.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0649661E-012
Vu = 1.0640763E-031
d = 0.8*h = 400.00
Nu = 4666.932
Ag = 125000.00
From (11.5.4.8), ACI 318-14: Vs = 132976.137
Av = 157079.633
fy = 444.44
s = 210.00
Vs is multiplied by Col = 1.00
s/d = 0.525
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 297085.704
bw = 250.00

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

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

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Section Height, H = 250.00
Section Width, W = 500.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($lb/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 115914.631$
Shear Force, $V2 = 4692.913$
Shear Force, $V3 = -3.1394051E-014$
Axial Force, $F = -4883.466$
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, $Db_L = 18.66667$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \gamma + p = 0.03239699$

- Calculation of γ -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00105998$ ((4.29), Biskinis Phd))
 $M_y = 1.7406E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.6421E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 20.00$
 $N = 4883.466$
 $E_c * I_g = 5.4737E+013$

Calculation of Yielding Moment M_y

Calculation of γ and M_y according to Annex 7 -

$\gamma = \min(\gamma_{ten}, \gamma_{com})$
 $\gamma_{ten} = 6.9055145E-006$
with $f_y = 444.44$
 $d = 457.00$
 $\gamma = 0.29584073$
 $A = 0.01813455$
 $B = 0.009964$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4883.466$
 $b = 250.00$
 $\gamma = 0.0940919$
 $\gamma_{comp} = 1.2695211E-005$
with $f_c = 20.00$
 $E_c = 21019.039$
 $\gamma = 0.29521167$
 $A = 0.0179136$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b/d

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

- Calculation of p -

From table 10-8: $p = 0.03133702$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_{yE}/V_{Col0E} = 0.76584669$

$d = 457.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00299199$

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

$b_w = 250.00$

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

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

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

$NUD = 4883.466$

$A_g = 125000.00$

$f_{cE} = 20.00$

$f_{ytE} = f_{ylE} = 444.44$

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

$b = 250.00$

$d = 457.00$

$f_{cE} = 20.00$

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

At local axis: 3

Integration Section: (b)