

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

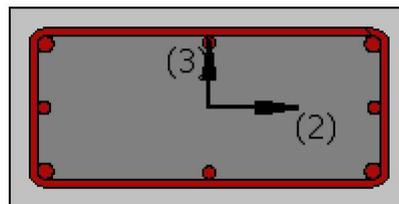
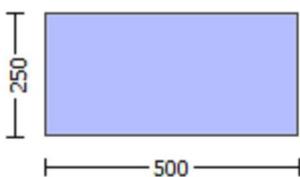
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, 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  $\gamma$  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

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Stepwise Properties

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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,  $D_{bL,ten} = 18.66667$

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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) =  $k_n l V_{CoI} = 170158.314$

$V_{CoI} = 170158.314$

$k_n l = 1.00$

displacement\_ductility\_demand = 0.01498372

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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).

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 $\phi = 1$  (normal-weight concrete)

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

$M/Vd = 4.00$

$M_u = 9.3055E+006$

$V_u = 3075.705$

$d = 0.8 \cdot h = 400.00$

$N_u = 4808.847$

$A_g = 125000.00$

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:  $V_s + V_f \leq 265721.532$   
 $bw = 250.00$

displacement\_ductility\_demand is calculated as  $\phi / y$

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

From analysis, chord rotation  $\theta = 0.00016016$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.01068896$  ((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  $\phi / y$  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  $p_t = 0.00725935$   
 $p_c = 0.00725935$   
 $p_v = 0.00351968$   
 $N = 4808.847$   
 $b = 250.00$   
 $\rho = 0.0940919$   
 $y_{comp} = 1.2695706E-005$   
with  $f_c = 20.00$   
 $E_c = 21019.039$   
 $y = 0.29520017$   
 $A = 0.0179155$   
 $B = 0.00986782$   
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

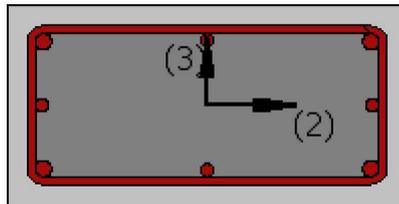
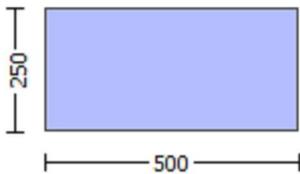
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

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

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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:  $As_{mid} = 402.1239$

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  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.1226E+008$   
 $Mu_{1+} = 1.1226E+008$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.1226E+008$   
 $Mu_{2+} = 1.1226E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the 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 the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

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

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$w_e$  (5.4c) = 0.00035724

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

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

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

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, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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

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Calculation of ratio lb/ld

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

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

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 555.55$$

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

$$y2 = 0.00231479$$

$$sh2 = 0.008$$

$$ft2 = 666.66$$

$$fy2 = 555.55$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = fs = 555.55$$

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

$$yv = 0.00231479$$

$$shv = 0.008$$

$$ftv = 666.66$$

$$fyv = 555.55$$

$$suv = 0.032$$

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  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

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

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

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

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

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

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$$

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/d

-----  
Adequate Lap Length: lb/d >= 1  
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Calculation of Mu2+  
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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/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.

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

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

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

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

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

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

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

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

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

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

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

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

with  $fs_v = fs = 555.55$

with  $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.22259049$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.22259049$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.10792266$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

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

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.29581556$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.29581556$

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

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  $Mu_2$ -  
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00020406$   
 $\mu = 1.1226E+008$

-----  
with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00225456$   
 $N = 4666.932$   
 $f_c = 20.00$   
 $\phi_{co} (5A.5, TBDY) = 0.002$   
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)  
From (5.4b), TBDY:  $\phi_{cu} = 0.00425603$   
 $w_e (5.4c) = 0.00035724$   
 $a_{se} ((5.4d), TBDY) = 0.02865579$   
 $b_o = 440.00$   
 $h_o = 190.00$   
 $b_{i2} = 459400.00$   
 $\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$   
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 ((5.A.5), 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  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$   
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  $fs_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, 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  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{u2\_nominal} = 0.08$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

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

$lo/lo_{u,min} = lb/d = 1.00$

$suv = 0.4 \cdot es_{u2\_nominal} ((5.5), TBDY) = 0.032$

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 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/fc) = 0.22259049$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/fc) = 0.22259049$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/fc) = 0.10792266$

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 =  $As_{l,ten}/(b \cdot d) \cdot (fs_1/fc) = 0.29581556$

2 =  $As_{l,com}/(b \cdot d) \cdot (fs_2/fc) = 0.29581556$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/fc) = 0.14342573$

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) ' $V_s = A_v \cdot fy \cdot d/s$ ' 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  $fc^{0.5} \leq 8.3$  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

-----  
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,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25*f_{sm} = 555.55$   
#####

Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.00  
Element Length, L = 3000.00  
Secondary Member  
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: 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:  $A_{st} = 0.00$   
-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,  $V_e/V_r = 0.76584669$   
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  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.8226E+008$   
 $M_{u2+} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $M_{u2-} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  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<sub>c</sub> = 20.00  
c<sub>o</sub> (5A.5, TBDY) = 0.002  
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)

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

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

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

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

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

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

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

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

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

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

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

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

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

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:  $lb/ld \geq 1$

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:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$fc = 20.00$$

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

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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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 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 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

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

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 555.55$$

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

$$y2 = 0.00231479$$

$$sh2 = 0.008$$

$$ft2 = 666.66$$

$$fy2 = 555.55$$

$$su2 = 0.032$$

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.

$$\text{with } fs2 = fs = 555.55$$

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

$$yv = 0.00231479$$

$$shv = 0.008$$

$$ftv = 666.66$$

$$fyv = 555.55$$

$$suv = 0.032$$

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  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

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

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

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

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

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

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021$$

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 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 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/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.

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

with  $fs_1 = fs = 555.55$

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

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

$su_2 = 0.4 \cdot esu_2, nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_2, nominal = 0.08$ ,

For calculation of  $esu_2, nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

with  $fs_2 = fs = 555.55$

with  $Es_2 = Es = 200000.00$

$y_v = 0.00231479$

$sh_v = 0.008$

$ft_v = 666.66$

$fy_v = 555.55$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

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

$su_v = 0.4 \cdot esuv, nominal ((5.5), TBDY) = 0.032$

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

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

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

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

with  $fsv = fs = 555.55$

with  $Esv = Es = 200000.00$

$1 = Asl, ten / (b \cdot d) \cdot (fs_1 / fc) = 0.20164653$

$2 = Asl, com / (b \cdot d) \cdot (fs_2 / fc) = 0.20164653$

$v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.09776801$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

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

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

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

$1 = Asl, ten / (b \cdot d) \cdot (fs_1 / fc) = 0.28396544$

$2 = Asl, com / (b \cdot d) \cdot (fs_2 / fc) = 0.28396544$

$v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.13768021$

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  $lb/d$

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

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

-----  
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 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

-----  
Calculation of Shear Strength at edge 2, Vr2 = 245709.058

Vr2 = 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 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,  $\phi = 1.00$   
 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,  $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = \phi \cdot u = 0.01295517$   
 $u = \phi \cdot u = 0.01295517$

- Calculation of  $\phi$  -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00944921$  ((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:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053E+012$   
 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  $\phi$  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 pt = 0.00801334  
pc = 0.00801334  
pv = 0.00388525  
N = 4808.847  
b = 500.00  
" = 0.20772947  
y\_comp = 2.5391411E-005  
with fc = 20.00  
Ec = 21019.039  
y = 0.32586105  
A = 0.01977629  
B = 0.01202411  
with Es = 200000.00

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length: lb/ld >= 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 lb/ld >= 1  
shear control ratio  $V_y E / V_{Col} O E = 0.66388728$

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.

NUD = 4808.847

Ag = 125000.00

f<sub>cE</sub> = 20.00

f<sub>yE</sub> = f<sub>yI</sub> = 444.44

pl =  $\text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01991193$

b = 500.00

d = 207.00

f<sub>cE</sub> = 20.00

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

At local axis: 2

Integration Section: (a)

-----  
**Calculation No. 3**

column C1, Floor 1

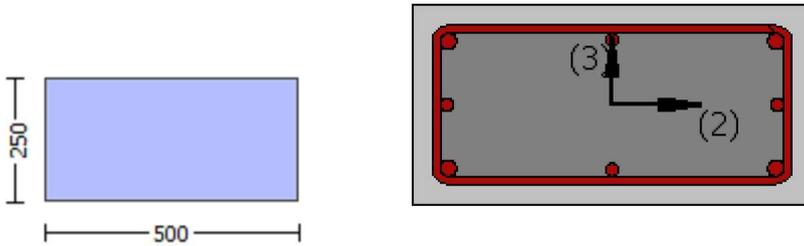
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, 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  $\gamma$  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:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 829.3805$   
-Compression:  $A_{sc,com} = 829.3805$   
-Middle:  $A_{st,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 100957.188$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 100957.188$   
 $V_{CoI} = 100957.188$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.00

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

= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 3.8643257E-011$   
 $V_u = 2.0575461E-014$   
 $d = 0.8 \cdot h = 200.00$   
 $N_u = 4808.847$   
 $A_g = 125000.00$   
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  $\phi_{CoI} = 0.00$   
 $s/d = 1.05$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 265721.532$   
 $b_w = 500.00$

displacement\_ductility\_demand is calculated as  $\phi / y$

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

From analysis, chord rotation  $\theta = 7.0354334E-022$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00944921$  ((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:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053E+012$   
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 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 1.5935853\text{E-}005$   
with  $f_y = 444.44$   
 $d = 207.00$   
 $y = 0.32634506$   
 $A = 0.02001647$   
 $B = 0.01212865$   
with  $pt = 0.00801334$   
 $pc = 0.00801334$   
 $pv = 0.00388525$   
 $N = 4808.847$   
 $b = 500.00$   
 $" = 0.20772947$   
 $y_{\text{comp}} = 2.5391411\text{E-}005$   
with  $fc = 20.00$   
 $E_c = 21019.039$   
 $y = 0.32586105$   
 $A = 0.01977629$   
 $B = 0.01202411$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

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

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

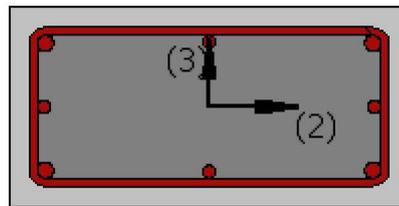
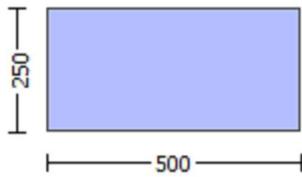
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

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 ( $l_o/l_{ou, \min} > 1$ )  
 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:  $A_{sl, t} = 0.00$   
 -Compression:  $A_{sl, c} = 2060.885$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl, ten} = 829.3805$   
 -Compression:  $A_{sl, com} = 829.3805$   
 -Middle:  $A_{sl, mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.66388728$

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 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 the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$   
-----

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

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

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)

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

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

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

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

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

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,  $n_s = 2.00$

$b_k = 500.00$   
-----

$\phi_{psh,y}$  (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:  $\phi_{cc} = 0.002$

$c$  = confinement factor = 1.00

$\phi_{y1} = 0.00231479$

$\phi_{sh1} = 0.008$

$f_{t1} = 666.66$

$f_{y1} = 555.55$

$\phi_{su1} = 0.032$

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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/d  
-----

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

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00020406$$

$$\mu_1 = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

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

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

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  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.22259049$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.22259049$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.10792266$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.29581556$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.29581556$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.14342573$$

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

---->

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

---->

$$su (4.9) = 0.24243176$$

$$\mu_u = MR_c (4.14) = 1.1226E+008$$

$$u = su (4.1) = 0.00020406$$

-----  
Calculation of ratio  $l_b/l_d$

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

-----  
Calculation of  $\mu_{u2+}$

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

$$u = 0.00020406$$

$$\mu_u = 1.1226E+008$$

-----  
with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

For calculation of  $esu1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

For calculation of  $esu2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$$y_2, sh_2, ft_2, fy_2, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$shv = 0.008$   
 $ftv = 666.66$   
 $fyv = 555.55$   
 $suv = 0.032$   
 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:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$   
 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:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 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 ((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.

y2, sh2,ft2,fy2, 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.

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

with  $f_{sv} = f_s = 555.55$

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

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

$c$  = 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

---

$\mu$  (4.9) = 0.24243176

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

$u = \mu$  (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,  $V_{r1} = 112732.921$

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

$V_{Co10} = 112732.921$

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

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

-----  
= 1 (normal-weight concrete)

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

$M/d = 2.00$

$\mu_u = 1.3332753E-012$

$\mu_v = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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  $Col = 0.00$

$s/d = 1.05$

$V_f$  ((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,  $V_{r2} = 112732.921$

$V_{r2} = V_{Co2}$  ((10.3), ASCE 41-17) =  $k_{nl} \cdot V_{Co10}$

$V_{Co10} = 112732.921$

$k_{nl} = 1$  (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

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

$M_{u1+} = 2.8226E+008$ , 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

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

$M_{u2+} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.2672130E-005$

$M_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

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

Final value of  $\phi_c$ :  $\phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_{cc}) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$\phi_{we}$  (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

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

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

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

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

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:  $cc = 0.002$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

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

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

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

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$$

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

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

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

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

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

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.20164653$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.20164653$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.28396544$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.28396544$$

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

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  $u$  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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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:  $l_b/d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.20164653$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.20164653$$

$$v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.28396544$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.28396544$$

$$v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.13768021$$

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  $l_b/l_d$

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

-----  
Calculation of  $Mu_2$ -

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

$$u = 8.2672130E-005$$

$$Mu = 2.8226E+008$$

-----  
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:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00425603$

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 = 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 =  $0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu1\_nominal} = 0.08$ ,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $\text{fs1} = \text{fs} = 555.55$

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

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 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu2\_nominal} = 0.08$ ,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $\text{fs2} = \text{fs} = 555.55$

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

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

Calculation of Shear Strength  $Vr = Min(Vr1,Vr2) = 245709.058$   
 -----

Calculation of Shear Strength at edge 1,  $Vr1 = 245709.058$

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

$VCol0 = 245709.058$

$knl = 1$  (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

-----  
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,  $M = -9.3055E+006$

Shear Force,  $V2 = -3075.705$

Shear Force,  $V3 = 2.0575461E-014$

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,  $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = * u = 0.01398453$   
 $u = y + p = 0.01398453$

- Calculation of  $y$  -

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

$My = 1.7405E+008$

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

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

factor = 0.30

$Ag = 125000.00$

$fc' = 20.00$

$N = 4808.847$

$Ec * Ig = 5.4737E+013$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

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

$y_{ten} = 6.9053083E-006$

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

$y_{comp} = 1.2695706E-005$

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:  $lb/d \geq 1$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.00329557$

with:

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

$d = 457.00$

$s = 0.00$

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

$A_v = 157.0796$ , 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.

$NUD = 4808.847$

$Ag = 125000.00$

$f_{cE} = 20.00$

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

$\rho_l = \text{Area\_Tot\_Long\_Rein}/(b*d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 20.00$

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

At local axis: 3

Integration Section: (a)

## Calculation No. 5

column C1, Floor 1

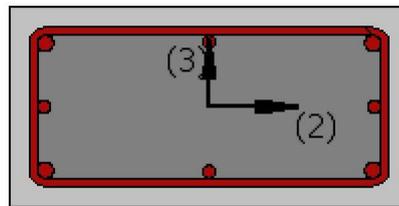
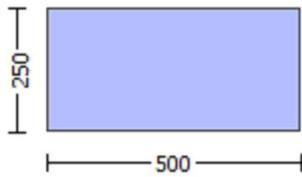
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column 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  $\gamma$  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:  $A_{sl} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

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

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

$\beta = 1$  (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 75969.712$   
 $V_u = 3075.705$   
 $d = 0.8 * h = 400.00$   
 $N_u = 4808.847$   
 $A_g = 125000.00$   
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:  $V_s + V_f \leq 265721.532$   
 $b_w = 250.00$

$displacement\_ductility\_demand$  is calculated as  $\delta / y$

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

From analysis, chord rotation  $\theta = 8.6245263E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00105989$  ((4.29), Bisquis 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  $\delta / y$  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

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

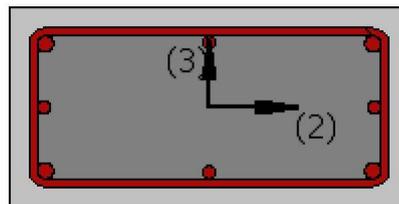
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( 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, = 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 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 the static loading combination

-----  
Calculation of  $M_{u1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

with  $E_s = E_s = 200000.00$   
 $y_v = 0.00231479$   
 $sh_v = 0.008$   
 $ft_v = 666.66$   
 $fy_v = 555.55$   
 $suv = 0.032$   
 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  
 $lo/lo_{min} = lb/ld = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.22259049$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.22259049$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.10792266$

and confined core properties:

$b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.29581556$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.29581556$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.14342573$

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  $Mu_1$ -  
 -----  
 -----

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

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

-----  
 with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00225456$   
 $N = 4666.932$   
 $fc = 20.00$   
 $co (5A.5, TBDY) = 0.002$   
 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 = 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/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  $e_{suv\_nominal}$  and  $\gamma_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$\gamma_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 555.55$

with  $E_{sv} = E_s = 200000.00$

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

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

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

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

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

$c$  = confinement factor = 1.00

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su$  (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  $Mu_{2+}$

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00425603$

$w_e$  (5.4c) = 0.00035724

$ase$  ((5.4d), TBDY) = 0.02865579

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.001496$

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

$A_{stir} = A_{stir} \cdot ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 500.00$

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.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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.24243176$$

$$Mu = MRc \text{ (4.14)} = 1.1226E+008$$

$$u = su \text{ (4.1)} = 0.00020406$$

Calculation of ratio  $l_b/l_d$

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

Calculation of  $Mu_2$ -

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

$$u = 0.00020406$$

$$Mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$fc = 20.00$$

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

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

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

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)

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 500.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 210.00$$

$$fywe = 555.55$$

$$fce = 20.00$$

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

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

$$y1 = 0.00231479$$

$$sh1 = 0.008$$

$$ft1 = 666.66$$

$f_{y1} = 555.55$   
 $s_{u1} = 0.032$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $s_{u1} = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08$ ,  
 For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = f_s = 555.55$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00231479$   
 $sh_2 = 0.008$   
 $ft_2 = 666.66$   
 $f_{y2} = 555.55$   
 $s_{u2} = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$   
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08$ ,  
 For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 555.55$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00231479$   
 $sh_v = 0.008$   
 $ft_v = 666.66$   
 $f_{y_v} = 555.55$   
 $s_{u_v} = 0.032$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $s_{u_v} = 0.4 * e_{su_v,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su_v,nominal} = 0.08$ ,  
 considering characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{su_v,nominal}$  and  $y_v, sh_v, ft_v, f_{y_v}$ , it is considered  
 characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s_v} = f_s = 555.55$   
 with  $E_{s_v} = E_s = 200000.00$   
 $1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.22259049$   
 $2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.22259049$   
 $v = A_{s1,mid}/(b*d)*(f_{s_v}/f_c) = 0.10792266$   
 and confined core properties:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.29581556$   
 $2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.29581556$   
 $v = A_{s1,mid}/(b*d)*(f_{s_v}/f_c) = 0.14342573$   
 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  $l_b/d$

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,  $V_{r1} = 112732.921$

$V_{r1} = V_{Col}$  ((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)

$M/Vd = 2.00$

$M_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

$V_s$  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:  $V_s + V_f \leq 297085.704$

$bw = 500.00$

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

$V_{r2} = V_{Col}$  ((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)

$M/Vd = 2.00$

$M_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

$V_s$  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:  $V_s + V_f \leq 297085.704$

$bw = 500.00$

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

At local axis: 3

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

Constant Properties

Knowledge Factor,  $\phi = 1.00$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25 * f_{sm} = 555.55$   
#####  
Section Height,  $H = 250.00$   
Section Width,  $W = 500.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
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: 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:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 829.3805$   
-Compression:  $A_{sl,com} = 829.3805$   
-Middle:  $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.76584669$   
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  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.8226E+008$

$\mu_{2+} = 2.8226E+008$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu_{1+} = 2.8226E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

-----  
 $s = 210.00$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

$y_1, sh_1, ft_1, fy_1$ , 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

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

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and  $y_2$ , sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$y_1$ , sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = fs = 555.55$$

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

$$yv = 0.00231479$$

$$shv = 0.008$$

$$ftv = 666.66$$

$$fyv = 555.55$$

$$suv = 0.032$$

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  $y_v$ , shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y_1$ , sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

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

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

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

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

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

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < v_{s,c}$  - 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 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:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

with  $E_s = E_s = 200000.00$   
 $y_v = 0.00231479$   
 $sh_v = 0.008$   
 $ft_v = 666.66$   
 $fy_v = 555.55$   
 $suv = 0.032$   
 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  
 $lo/lou, min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , 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:

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

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

---

$v < v_{s,c}$  - 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  $Mu_{2+}$   
 -----  
 -----

-----  
 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  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00425603$   
 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 = 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/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  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

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

with  $f_{sv} = f_s = 555.55$

with  $E_{sv} = E_s = 200000.00$

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

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

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

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

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

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

$c$  = confinement factor = 1.00

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.15301708

$Mu = MRc$  (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  $Mu_2$ -

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00425603$

$w_e$  (5.4c) = 0.00035724

$ase$  ((5.4d), TBDY) = 0.02865579

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.001496$

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

$A_{stir} = A_{stir} \cdot ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 500.00$

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.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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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

--->

$$s_u (4.9) = 0.15301708$$

$$M_u = MR_c (4.14) = 2.8226E+008$$

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

Calculation of ratio  $l_b/l_d$

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

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

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

$$V_{r1} = V_{CoI} ((10.3), ASCE 41-17) = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 245709.058$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$M_u = 2.0649661E-012$$

$$V_u = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

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

$$A_v = 157079.633$$

$$f_y = 444.44$$

$$s = 210.00$$

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

$$s/d = 0.525$$

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

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

$$b_w = 250.00$$

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

$$V_{r2} = V_{CoI} ((10.3), ASCE 41-17) = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 245709.058$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$M_u = 2.0649661E-012$$

$$V_u = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

From (11.5.4.8), ACI 318-14:  $V_s = 132976.137$   
 $A_v = 157079.633$   
 $f_y = 444.44$   
 $s = 210.00$   
 $V_s$  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  $y$  -

$$y = (M_y * L_s / 3) / E_{eff} = 0.00944921 \text{ ((4.29), Biskinis Phd)}$$
$$M_y = 7.7583E+007$$
$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$$

From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 4.1053E+012$

$$\text{factor} = 0.30$$
$$A_g = 125000.00$$
$$f_c' = 20.00$$
$$N = 4808.847$$
$$E_c * I_g = 1.3684E+013$$

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  $V_y E / V_{col} O E = 0.66388728$

$$d = 207.00$$

$$s = 0.00$$

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

$A_v = 157.0796$ , 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.

$$N_{UD} = 4808.847$$

$$A_g = 125000.00$$

$$f_c E = 20.00$$

$$f_y E = f_y I E = 444.44$$

$$p_l = \text{Area}_{Tot\_Long\_Rein} / (b * d) = 0.01991193$$

$$b = 500.00$$

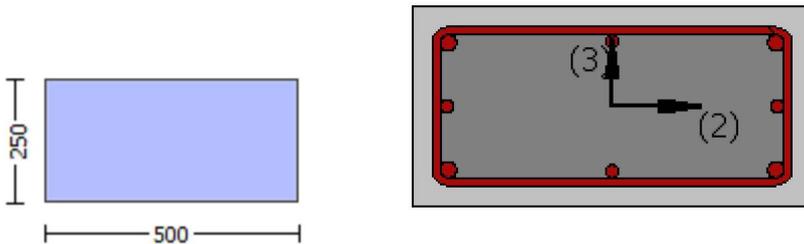
$$d = 207.00$$

$$f_c E = 20.00$$

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 VRd  
Edge: End  
Local Axis: (3)



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

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, 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  $\gamma$  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,  $M_a = -3.8643257E-011$   
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:  $A_{st} = 0.00$   
-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,  $D_{bL,ten} = 18.66667$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 100957.188$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{Col} = 100957.188$   
 $V_{Col} = 100957.188$   
 $k_n = 1.00$   
 $displacement\_ductility\_demand = 0.00$   
-----

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

-----  
= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 2.3093644E-011$   
 $V_u = 2.0575461E-014$   
 $d = 0.8 \cdot h = 200.00$   
 $N_u = 4808.847$   
 $A_g = 125000.00$   
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  $\phi_{Col} = 0.00$   
 $s/d = 1.05$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 265721.532$   
 $b_w = 500.00$   
-----

-----  
 $displacement\_ductility\_demand$  is calculated as / y  
-----

- Calculation of  $\phi_y$  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:  $E_{eff} = \text{factor} * E_c * I_g = 4.1053E+012$   
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  $\phi_y$  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  $p_t = 0.00801334$   
 $p_c = 0.00801334$   
 $p_v = 0.00388525$   
 $N = 4808.847$   
 $b = 500.00$   
 $\mu = 0.20772947$   
 $y_{comp} = 2.5391411E-005$   
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  $l_b/d$

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

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

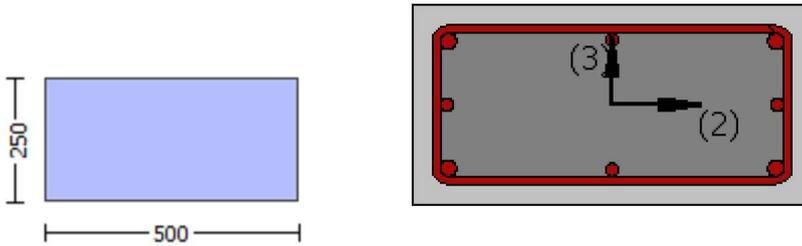
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: End

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.00

Element Length,  $L = 3000.00$

Secondary Member

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:  $As_{,ten} = 829.3805$

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

-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

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.1226E+008$

$Mu_{1+} = 1.1226E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.1226E+008$

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

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00225456$

$N = 4666.932$

$f_c = 20.00$

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

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)

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

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

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

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

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

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:  $cc = 0.002$

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

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

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

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

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_2_{nominal} = 0.08$ ,

For calculation of  $esu_2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

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

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

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

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

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.22259049$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.22259049$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.10792266$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.29581556$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.29581556$$

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

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

--->

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

--->

$$s_u(4.9) = 0.24243176$$

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

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

Calculation of ratio  $l_b/d$

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

Calculation of  $\mu_{u1}$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00020406$$

$$\mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00425603$$

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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/d  
-----

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

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00020406$$

$$\mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

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

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$$

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  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.22259049$$

$$2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.22259049$$

$$v = A_{sl,mid}/(b * d) * (fs_v/f_c) = 0.10792266$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b * d) * (fs_1/f_c) = 0.29581556$$

$$2 = A_{sl,com}/(b * d) * (fs_2/f_c) = 0.29581556$$

$$v = A_{sl,mid}/(b * d) * (fs_v/f_c) = 0.14342573$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.24243176$$

$$\mu_u = MR_c (4.14) = 1.1226E+008$$

$$u = su (4.1) = 0.00020406$$

-----  
Calculation of ratio  $l_b/l_d$

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

-----  
Calculation of  $\mu_u$ -

-----  
Calculation of ultimate curvature  $\mu_u$  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

fc = 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 = 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 =  $0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu1\_nominal} = 0.08$ ,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $\text{fs1} = \text{fs} = 555.55$

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

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 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $\text{esu2\_nominal} = 0.08$ ,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $\text{fs2} = \text{fs} = 555.55$

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

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

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

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

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

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

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

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.29581556$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.29581556$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.14342573$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

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

---

$$su (4.9) = 0.24243176$$

$$\text{Mu} = \text{MRc} (4.14) = 1.1226\text{E}+008$$

$$u = su (4.1) = 0.00020406$$

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length: lb/ld >= 1

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 112732.921

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

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

$$VColO = 112732.921$$

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

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

-----  
= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\text{Mu} = 1.3332753\text{E}-012$$

$$Vu = 7.2890426\text{E}-033$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

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

-----  
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 <= 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  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 2.8226E+008$   
 $Mu_{1+} = 2.8226E+008$ , 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 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 the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

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

-----  
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  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.00425603$   
 $\phi_{ue} (5.4c) = 0.00035724$   
 $\phi_{ase} ((5.4d), TBDY) = 0.02865579$   
 $bo = 440.00$   
 $ho = 190.00$   
 $bi2 = 459400.00$

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/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  $E_{sv} = E_s = 200000.00$

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

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

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

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

$c$  = 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  $l_b/d$

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

-----  
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:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$s = 210.00$   
 $f_{ywe} = 555.55$   
 $f_{ce} = 20.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00231479$   
 $sh_1 = 0.008$   
 $ft_1 = 666.66$   
 $fy_1 = 555.55$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 1.00$   
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 1.00$   
 $suv = 0.4 * esuv \text{ nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.20164653$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.20164653$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.09776801$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, \text{TBDY}) = 20.00$   
 $cc (5A.5, \text{TBDY}) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.28396544$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.28396544$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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:  $l_b/d \geq 1$

Calculation of  $\mu_2$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu_u = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$lo/lo_{u,min} = lb/lb_{u,min} = 1.00$$

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$yv = 0.00231479$$

$$shv = 0.008$$

$$ftv = 666.66$$

$$fyv = 555.55$$

$$suv = 0.032$$

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

$$lo/lo_{u,min} = lb/d = 1.00$$

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

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.

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.20164653$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.20164653$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.28396544$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.28396544$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.13768021$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - 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  $lb/d$

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

-----  
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) ' $V_s = A_v * fy * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '

where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$\nu_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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) =  $k_n I \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 245709.058$

$k_n I = 1$  (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)

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$\nu_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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,  $\phi = 1.00$

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,  $M = 75969.712$   
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:  $A_{s,ten} = 829.3805$   
-Compression:  $A_{s,com} = 829.3805$   
-Middle:  $A_{s,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_bL = 18.66667$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = * u = 0.00435547$   
 $u = y + p = 0.00435547$

-----  
- 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  $V_y E / V_{Col} O E = 0.76584669$

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

bw = 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 = 4808.847

Ag = 125000.00

f<sub>cE</sub> = 20.00

f<sub>yE</sub> = f<sub>yI</sub> = 444.44

pl =  $\text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01803838$

b = 250.00

d = 457.00

f<sub>cE</sub> = 20.00

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

At local axis: 3

Integration Section: (b)

-----  
**Calculation No. 9**

column C1, Floor 1

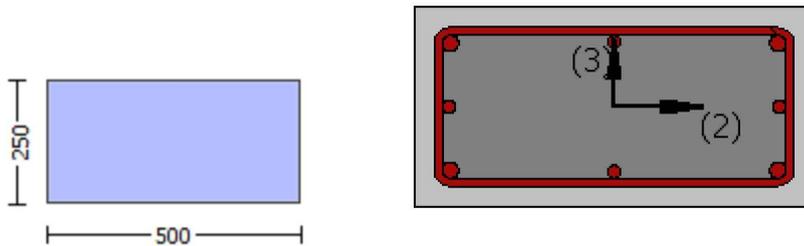
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, 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  $\gamma$  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:  $A_{sl,t} = 1231.504$   
-Compression:  $A_{sl,c} = 829.3805$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 829.3805$   
-Compression:  $A_{sl,com} = 829.3805$   
-Middle:  $A_{sl,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 170165.705$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 170165.705$   
 $V_{CoI} = 170165.705$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.02286035

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

= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 1.4198E+007$   
 $V_u = 4692.913$   
 $d = 0.8 \cdot h = 400.00$   
 $N_u = 4883.466$   
 $A_g = 125000.00$   
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  $\phi_{CoI} = 1.00$   
 $s/d = 0.525$   
 $V_f$  ((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  $\phi / y$

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

From analysis, chord rotation = 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:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.6421E+013$   
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  $l_b/d$

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

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

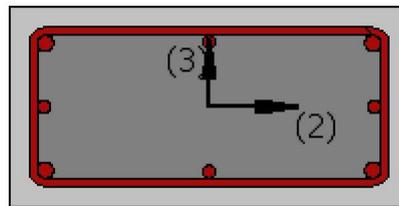
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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 ( $l_o/l_{ou, \min} >= 1$ )  
 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:  $A_{sl,t} = 0.00$   
 -Compression:  $A_{sl,c} = 2060.885$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl,ten} = 829.3805$   
 -Compression:  $A_{sl,com} = 829.3805$   
 -Middle:  $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.66388728$

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 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 the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  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, TBDY) = 0.002

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$w_e$  (5.4c) = 0.00035724

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

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

$c$  = 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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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/d  
-----

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

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00020406$$

$$\mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

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

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

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  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.22259049$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.22259049$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.10792266$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.29581556$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.29581556$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.14342573$$

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  $Mu_{2+}$

-----  
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:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00425603$   
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  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirrups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00299199  
Ash =  $\text{Astir} * ns = 78.53982$   
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  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , 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  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$   
 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:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 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.

y2, sh2,ft2,fy2, 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.

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

with  $f_{sv} = f_s = 555.55$

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:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$\mu \text{ (4.9)} = 0.24243176$

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

$u = \mu \text{ (4.1)} = 0.00020406$

-----  
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,  $V_{r1} = 112732.921$

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

$V_{Co10} = 112732.921$

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

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

-----  
 $= 1$  (normal-weight concrete)

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

$M/d = 2.00$

$\mu_u = 1.3332753E-012$

$\mu_v = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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,  $V_{r2} = 112732.921$

$V_{r2} = V_{Co2} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Co10}$

$V_{Co10} = 112732.921$

$k_{nl} = 1$  (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

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

$M_{u1+} = 2.8226E+008$ , 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

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

$M_{u2+} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.2672130E-005$

$M_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

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

Final value of  $\phi_c$ :  $\phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$\phi_w$  (5.4c) = 0.00035724

$\phi_{ase}$  ((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,  $n_s = 2.00$

$b_k = 250.00$

$s = 210.00$   
 $f_{ywe} = 555.55$   
 $f_{ce} = 20.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00231479$   
 $sh_1 = 0.008$   
 $ft_1 = 666.66$   
 $fy_1 = 555.55$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.20164653$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.20164653$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.09776801$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$   
 $cc \text{ (5A.5, TBDY)} = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.28396544$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.28396544$

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

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  $u$  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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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:  $l_b/d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

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

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

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

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

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

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

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

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.20164653$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.20164653$$

$$v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.28396544$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.28396544$$

$$v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.13768021$$

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  $l_b/l_d$

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

-----  
Calculation of  $Mu_2$ -

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

$$u = 8.2672130E-005$$

$$Mu = 2.8226E+008$$

-----  
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:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00425603$   
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  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirrups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00299199  
Ash =  $\text{Astir} * ns = 78.53982$   
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 =  $0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$   
From table 5A.1, TBDY:  $\text{esu1\_nominal} = 0.08$ ,  
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 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$   
From table 5A.1, TBDY:  $\text{esu2\_nominal} = 0.08$ ,  
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  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.28396544$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.28396544$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.13768021$   
 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:  $lb/ld \geq 1$   
 -----  
 -----  
 -----

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  $Vf$  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

-----  
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  $fc'^{0.5} <= 8.3$  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 ( $lb/d >= 1$ )  
No FRP Wrapping

## Stepwise Properties

Bending Moment,  $M = -5.9662941E-011$

Shear Force,  $V2 = -4692.913$

Shear Force,  $V3 = 3.1394051E-014$

Axial Force,  $F = -4883.466$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 1231.504$

-Compression:  $As_c = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle:  $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement,  $Db_L = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = \rho_y u + \rho_p u = 0.03298859$

- Calculation of  $\rho_y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00945001$  ((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  $\rho_y$  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  $p_t = 0.00801334$

$p_c = 0.00801334$

$p_v = 0.00388525$

$N = 4883.466$

$b = 500.00$

$\rho = 0.20772947$

$y_{comp} = 2.5390422E-005$

with  $f_c = 20.00$

$E_c = 21019.039$

$y = 0.32587375$

$A = 0.01977419$

$B = 0.01202411$

with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

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

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.02353857$

with:

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

shear control ratio  $V_{yE}/V_{CoIE} = 0.66388728$

$d = 207.00$

$s = 0.00$

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

$A_v = 157.0796$ , 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.

$NUD = 4883.466$

$Ag = 125000.00$

$f_{cE} = 20.00$

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

$\rho_l = \text{Area\_Tot\_Long\_Rein}/(b*d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 20.00$

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

At local axis: 2

Integration Section: (a)

## Calculation No. 11

column C1, Floor 1

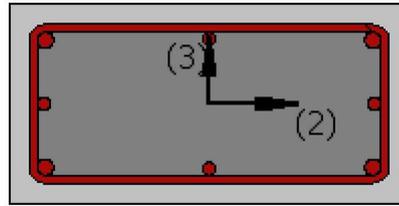
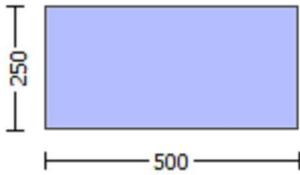
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, 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  $\gamma$  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:  $A_{sl} = 1231.504$

-Compression:  $A_{sc} = 829.3805$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 100971.97$   
 $V_n ((10.3), ASCE 41-17) = k_n \phi V_{CoI} = 100971.97$   
 $V_{CoI} = 100971.97$   
 $k_n = 1.00$   
 $displacement\_ductility\_demand = 0.00$

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

$\phi = 1$  (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 5.9662941E-011$   
 $V_u = 3.1394051E-014$   
 $d = 0.8 \cdot h = 200.00$   
 $N_u = 4883.466$   
 $A_g = 125000.00$   
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  $\phi_{CoI} = 0.00$   
 $s/d = 1.05$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 265721.532$   
 $b_w = 500.00$

$displacement\_ductility\_demand$  is calculated as  $\phi / y$

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

From analysis, chord rotation  $\phi = 1.0734668E-021$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00945001$  ((4.29), Biskinis Phd)  
 $M_y = 7.7590E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 4.1053E+012$   
 $factor = 0.30$   
 $A_g = 125000.00$   
 $f_c' = 20.00$   
 $N = 4883.466$   
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  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

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

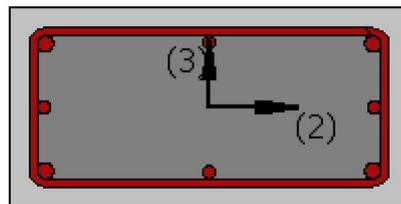
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( u)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 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 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 the static loading combination

-----  
Calculation of  $M_{u1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.00020406$

$M_u = 1.1226E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

with  $E_s = E_s = 200000.00$   
 $y_v = 0.00231479$   
 $sh_v = 0.008$   
 $ft_v = 666.66$   
 $fy_v = 555.55$   
 $suv = 0.032$   
 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  
 $lo/lo_{min} = lb/ld = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.22259049$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.22259049$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.10792266$

and confined core properties:

$b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.29581556$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.29581556$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.14342573$

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  $Mu_1$ -  
 -----  
 -----

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

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

with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00225456$   
 $N = 4666.932$   
 $fc = 20.00$   
 $co (5A.5, TBDY) = 0.002$   
 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 = 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/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  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

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

with  $f_{sv} = f_s = 555.55$

with  $E_{sv} = E_s = 200000.00$

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

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

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

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

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

$c$  = confinement factor = 1.00

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su$  (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  $Mu_{2+}$

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00425603$

$w_e$  (5.4c) = 0.00035724

$ase$  ((5.4d), TBDY) = 0.02865579

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.001496$

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

$A_{stir} = A_{stir} \cdot ns = 78.53982$

No stirrups,  $ns = 2.00$

$bk = 500.00$

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.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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.24243176$$

$$Mu = MRc \text{ (4.14)} = 1.1226E+008$$

$$u = su \text{ (4.1)} = 0.00020406$$

Calculation of ratio  $l_b/l_d$

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

Calculation of  $Mu_2$ -

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

$$u = 0.00020406$$

$$Mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$fc = 20.00$$

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

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

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

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)

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 500.00$$

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

$$Ash = Astir*ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 210.00$$

$$fywe = 555.55$$

$$fce = 20.00$$

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

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

$$y1 = 0.00231479$$

$$sh1 = 0.008$$

$$ft1 = 666.66$$

$f_{y1} = 555.55$   
 $s_{u1} = 0.032$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $s_{u1} = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08$ ,  
 For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = f_s = 555.55$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.00231479$   
 $sh_2 = 0.008$   
 $ft_2 = 666.66$   
 $f_{y2} = 555.55$   
 $s_{u2} = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$   
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08$ ,  
 For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = f_s = 555.55$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.00231479$   
 $sh_v = 0.008$   
 $ft_v = 666.66$   
 $f_{y_v} = 555.55$   
 $s_{u_v} = 0.032$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $s_{u_v} = 0.4 * e_{su_v,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su_v,nominal} = 0.08$ ,  
 considering characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{su_v,nominal}$  and  $y_v, sh_v, ft_v, f_{y_v}$ , it is considered  
 characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s_v} = f_s = 555.55$   
 with  $E_{s_v} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22259049$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22259049$   
 $v = A_{sl,mid}/(b*d)*(f_{s_v}/f_c) = 0.10792266$   
 and confined core properties:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29581556$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.29581556$   
 $v = A_{sl,mid}/(b*d)*(f_{s_v}/f_c) = 0.14342573$   
 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  $l_b/d$

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,  $V_{r1} = 112732.921$

$V_{r1} = V_{Col}$  ((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)

$M/Vd = 2.00$

$M_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

$V_s$  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:  $V_s + V_f \leq 297085.704$

$bw = 500.00$

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

$V_{r2} = V_{Col}$  ((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)

$M/Vd = 2.00$

$M_u = 1.3332753E-012$

$V_u = 7.2890426E-033$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 444.44$

$s = 210.00$

$V_s$  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:  $V_s + V_f \leq 297085.704$

$bw = 500.00$

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

At local axis: 3

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

Constant Properties

Knowledge Factor,  $\phi = 1.00$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Existing material: Steel Strength,  $f_s = 1.25 * f_{sm} = 555.55$   
#####  
Section Height,  $H = 250.00$   
Section Width,  $W = 500.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
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: 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:  $A_{st} = 0.00$   
-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,  $V_e/V_r = 0.76584669$   
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  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.8226E+008$

$\mu_{2+} = 2.8226E+008$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu = 2.8226E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

-----  
 $s = 210.00$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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.

$y_1, sh_1, ft_1, fy_1$ , 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

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

$$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 555.55$$

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

$$yv = 0.00231479$$

$$shv = 0.008$$

$$ftv = 666.66$$

$$fyv = 555.55$$

$$suv = 0.032$$

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

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

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

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

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

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

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.28396544$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.28396544$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.13768021$$

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:  $lb/ld \geq 1$

-----  
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:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$$w_e (5.4c) = 0.00035724$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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)

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

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

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

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$f_{t1} = 666.66$$

$$f_{y1} = 555.55$$

$$su_1 = 0.032$$

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

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

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

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

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

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

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

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

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$f_{t2} = 666.66$$

$$f_{y2} = 555.55$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = fs = 555.55$$

with  $E_s = E_s = 200000.00$   
 $y_v = 0.00231479$   
 $sh_v = 0.008$   
 $ft_v = 666.66$   
 $fy_v = 555.55$   
 $suv = 0.032$   
 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  
 $lo/lo_{min} = lb/ld = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = Es = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.20164653$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.20164653$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.09776801$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.28396544$   
 $2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.28396544$   
 $v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.13768021$   
 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  $Mu_{2+}$   
 -----  
 -----

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:  $cu = 0.00425603$   
 $we (5.4c) = 0.00035724$

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/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  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$ , 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:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

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

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

$c$  = confinement factor = 1.00

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

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

--->

$\mu_u$  (4.9) = 0.15301708

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

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

-----  
Calculation of ratio  $l_b/d$

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

-----  
Calculation of  $\mu_u$ -

-----  
Calculation of ultimate curvature  $\mu_u$  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  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, cc) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$w_e$  (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

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

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.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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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

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

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

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

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

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

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

--->

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

--->

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

$$M_u = MR_c \text{ (4.14)} = 2.8226E+008$$

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

Calculation of ratio  $l_b/l_d$

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

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

Calculation of Shear Strength at edge 1,  $V_{r1} = 245709.058$

$$V_{r1} = V_{CoI} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 245709.058$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0649661E-012$$

$$V_u = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 132976.137$$

$$A_v = 157079.633$$

$$f_y = 444.44$$

$$s = 210.00$$

$$V_s \text{ is multiplied by } \text{Col} = 1.00$$

$$s/d = 0.525$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 297085.704$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 245709.058$

$$V_{r2} = V_{CoI} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{CoI0}$$

$$V_{CoI0} = 245709.058$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f_c' = 20.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0649661E-012$$

$$V_u = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

From (11.5.4.8), ACI 318-14:  $V_s = 132976.137$   
 $A_v = 157079.633$   
 $f_y = 444.44$   
 $s = 210.00$   
 $V_s$  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,  $\gamma = 1.00$   
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,  $M = -1.4198E+007$   
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:  $A_{st} = 1231.504$   
-Compression:  $A_{sc} = 829.3805$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 829.3805$   
-Compression:  $A_{sc,com} = 829.3805$   
-Middle:  $A_{s,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $DbL = 18.66667$

-----  
-----  
Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = \gamma \cdot u = 0.04202682$   
 $u = \gamma + p = 0.04202682$

- Calculation of  $y$  -

$$y = (M_y * L_s / 3) / E_{eff} = 0.01068981 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.7406E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1*L \text{ and } L_s < 2*L) = 3025.481$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.6421E+013$$

$$\text{factor} = 0.30$$

$$A_g = 125000.00$$

$$f_c' = 20.00$$

$$N = 4883.466$$

$$E_c * I_g = 5.4737E+013$$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$$y = \text{Min}(y_{ten}, y_{com})$$

$$y_{ten} = 6.9055145E-006$$

$$\text{with } f_y = 444.44$$

$$d = 457.00$$

$$y = 0.29584073$$

$$A = 0.01813455$$

$$B = 0.009964$$

$$\text{with } p_t = 0.00725935$$

$$p_c = 0.00725935$$

$$p_v = 0.00351968$$

$$N = 4883.466$$

$$b = 250.00$$

$$" = 0.0940919$$

$$y_{comp} = 1.2695211E-005$$

$$\text{with } f_c = 20.00$$

$$E_c = 21019.039$$

$$y = 0.29521167$$

$$A = 0.0179136$$

$$B = 0.00986782$$

$$\text{with } E_s = 200000.00$$

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  $l_b/d \geq 1$

$$\text{shear control ratio } V_y E / V_{CoI} E = 0.76584669$$

$$d = 457.00$$

$$s = 0.00$$

$$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00299199$$

$A_v = 157.0796$ , 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.

$$N_{UD} = 4883.466$$

$$A_g = 125000.00$$

$$f_c E = 20.00$$

$$f_y E = f_y I E = 444.44$$

$$p_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b * d) = 0.01803838$$

$$b = 250.00$$

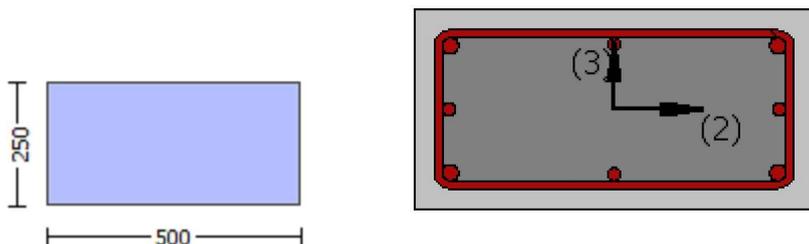
$$d = 457.00$$

$$f_c E = 20.00$$

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  $\gamma$  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 ( $l_o/l_{o,u,min} = l_b/l_d >= 1$ )  
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:  $A_{st} = 0.00$   
-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,  $Db_{L,ten} = 18.66667$

-----  
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) ' $V_s = A_v \phi_f y d / s$ ' is replaced by ' $V_s + \phi_f V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c^{0.5} <= 8.3$  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  $\phi_{CoI} = 1.00$   
 $s/d = 0.525$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f <= 265721.532$   
 $b_w = 250.00$   
-----

-----  
 $displacement\_ductility\_demand$  is calculated as / y  
-----

- Calculation of  $\phi_y$  for END B -  
for rotation axis 3 and integ. section (b)

From analysis, chord rotation  $\theta = 0.00013159$   
 $\phi_y = (M_y \cdot L_s / 3) / E_{eff} = 0.00105998$  ((4.29), Biskinis Phd))  
 $M_y = 1.7406E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 300.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.6421E+013$   
factor = 0.30  
 $A_g = 125000.00$   
 $f_c' = 20.00$   
 $N = 4883.466$   
 $E_c \cdot I_g = 5.4737E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

$\phi_y = \text{Min}(\phi_{y\_ten}, \phi_{y\_com})$   
 $\phi_{y\_ten} = 6.9055145E-006$   
with  $f_y = 444.44$   
 $d = 457.00$   
 $\phi_y = 0.29584073$   
 $A = 0.01813455$   
 $B = 0.009964$   
with  $p_t = 0.00725935$   
 $p_c = 0.00725935$   
 $p_v = 0.00351968$   
 $N = 4883.466$   
 $b = 250.00$   
 $\phi_{y\_comp} = 1.2695211E-005$   
with  $f_c = 20.00$   
 $E_c = 21019.039$   
 $\phi_y = 0.29521167$   
 $A = 0.0179136$   
 $B = 0.00986782$   
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

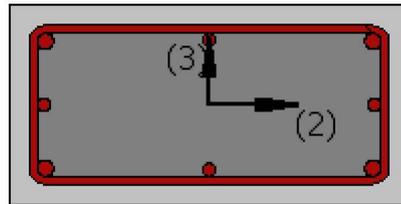
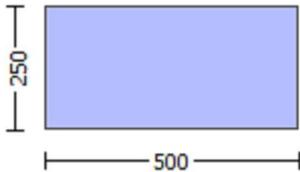
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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 ( $l_o/l_{ou, \min} \geq 1$ )

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:  $As_{c,mid} = 402.1239$

-----  
-----  
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 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 the static loading combination

-----  
Calculation of  $\mu_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 0.00020406$   
 $\mu_u = 1.1226E+008$

-----  
with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00225456$   
 $N = 4666.932$   
 $f_c = 20.00$   
 $\alpha_1$  (5A.5, TBDY) = 0.002  
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00425603$   
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  
 $\alpha_1$  ((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.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00231479$   
 $sh_1 = 0.008$   
 $ft_1 = 666.66$   
 $fy_1 = 555.55$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 1.00$   
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/d = 1.00$   
 $suv = 0.4 * esuv \text{ nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.22259049$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.22259049$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.10792266$   
 and confined core properties:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, \text{TBDY}) = 20.00$   
 $cc (5A.5, \text{TBDY}) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.29581556$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.29581556$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14342573$$

Case/Assumption: Unconfined full section - Steel rupture  
' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.24243176$$

$$\mu = M_{Rc}(4.14) = 1.1226E+008$$

$$u = s_u(4.1) = 0.00020406$$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\mu_{u1}$ -

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.00020406$$

$$\mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00425603$$

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)

$$p_{sh, x}(5.4d) = 0.001496$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00299199$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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/d  
-----

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00020406$$

$$\mu = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00425603$$

$$w_e \text{ (5.4c)} = 0.00035724$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.001496$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00299199$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

$$l_o/l_{o,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

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.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

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  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 555.55$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_v = fs = 555.55$$

$$\text{with } Es_v = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.22259049$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.22259049$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.10792266$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.29581556$$

$$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.29581556$$

$$v = A_{sl,mid}/(b*d) * (fs_v/f_c) = 0.14342573$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.24243176$$

$$Mu = MRc (4.14) = 1.1226E+008$$

$$u = su (4.1) = 0.00020406$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $Mu_2$ -

-----  
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 ((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.

$y2, sh2, ft2, fy2$ , 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:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$   
 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:  $lb/ld \geq 1$   
 -----  
 -----  
 -----

-----  
 Calculation of Shear Strength  $Vr = Min(Vr1,Vr2) = 112732.921$   
 -----

Calculation of Shear Strength at edge 1,  $Vr1 = 112732.921$   
 $Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$   
 $VColO = 112732.921$   
 $knl = 1$  (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

-----  
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  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 2.8226E+008$   
 $Mu_{1+} = 2.8226E+008$ , 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 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 the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.2672130E-005$   
 $Mu = 2.8226E+008$

-----  
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  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.00425603$   
 $\phi_{ue} (5.4c) = 0.00035724$   
 $\phi_{ase} ((5.4d), TBDY) = 0.02865579$   
 $b_o = 440.00$   
 $h_o = 190.00$   
 $bi_2 = 459400.00$

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/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 = fs/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 = fs/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  $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.20164653$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.20164653$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$c$  = 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  $l_b/d$

-----  
Adequate Lap Length:  $l_b/d \geq 1$

-----  
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:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

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)

$$p_{sh,x} (5.4d) = 0.001496$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00299199$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$s = 210.00$   
 $f_{ywe} = 555.55$   
 $f_{ce} = 20.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00231479$   
 $sh_1 = 0.008$   
 $ft_1 = 666.66$   
 $fy_1 = 555.55$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.20164653$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.20164653$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.09776801$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$   
 $cc \text{ (5A.5, TBDY)} = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.28396544$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.28396544$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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)

$$p_{sh, x}(5.4d) = 0.001496$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00299199$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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:  $l_b/d \geq 1$

Calculation of  $\mu_2$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00425603$$

$$w_e \text{ (5.4c)} = 0.00035724$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.001496$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00299199$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

$$l_o/l_{o,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

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.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$lo/lo_{u,min} = lb/lb_{u,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 555.55$$

$$\text{with } Es_2 = Es = 200000.00$$

$$yv = 0.00231479$$

$$shv = 0.008$$

$$ftv = 666.66$$

$$fyv = 555.55$$

$$suv = 0.032$$

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

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

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.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 555.55$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.20164653$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.20164653$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.28396544$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.28396544$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.13768021$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - 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  $V_r = \text{Min}(V_{r1}, V_{r2}) = 245709.058$

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) ' $V_s = A_v * fy * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ '

where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$\nu_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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) =  $k_n I \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 245709.058$

$k_n = 1$  (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)

$M/Vd = 2.00$

$\mu_u = 2.0649661E-012$

$\nu_u = 1.0640763E-031$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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,  $\phi = 1.00$

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,  $M = -3.4535259E-011$   
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:  $A_{s,ten} = 829.3805$   
-Compression:  $A_{s,com} = 829.3805$   
-Middle:  $A_{s,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_bL = 18.66667$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = * u = 0.03298859$   
 $u = y + p = 0.03298859$

-----  
- 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  $V_y E / V_{Col} O E = 0.66388728$

d = 207.00

s = 0.00

t =  $A_v / (b w * s) + 2 * t_f / b w * (f_f e / f_s) = 0.001496$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

bw = 500.00

The term  $2 * t_f / b w * (f_f e / f_s)$  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  $f_f e / f_s$  normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

NUD = 4883.466

Ag = 125000.00

f<sub>cE</sub> = 20.00

f<sub>yE</sub> = f<sub>yI</sub> = 444.44

pl =  $\text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01991193$

b = 500.00

d = 207.00

f<sub>cE</sub> = 20.00

-----  
End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 2

Integration Section: (b)

-----  
**Calculation No. 15**

column C1, Floor 1

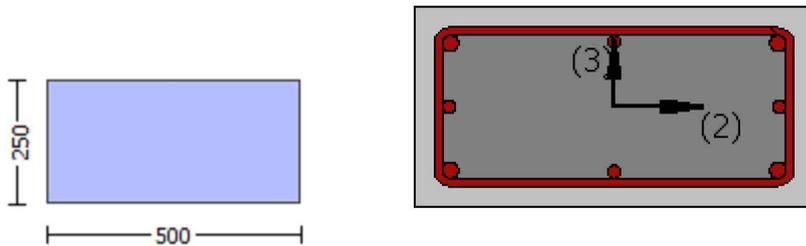
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, 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  $\gamma$  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:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 829.3805$   
-Compression:  $A_{sc,com} = 829.3805$   
-Middle:  $A_{st,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 100971.97$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 100971.97$   
 $V_{CoI} = 100971.97$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.00

NOTE: In expression (10-3) ' $V_s = A_v \phi_f y d / s$ ' is replaced by ' $V_s + \phi V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
 $f_c' = 16.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 3.4535259E-011$   
 $V_u = 3.1394051E-014$   
 $d = 0.8 \cdot h = 200.00$   
 $N_u = 4883.466$   
 $A_g = 125000.00$   
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  $\phi_{CoI} = 0.00$   
 $s/d = 1.05$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 265721.532$   
 $b_w = 500.00$

displacement\_ductility\_demand is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END B -  
for rotation axis 2 and integ. section (b)

From analysis, chord rotation  $\theta = 4.7176720E-022$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00945001$  ((4.29), Biskinis Phd)  
 $M_y = 7.7590E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 4.1053E+012$   
factor = 0.30  
 $A_g = 125000.00$   
 $f_c' = 20.00$   
 $N = 4883.466$   
 $E_c \cdot I_g = 1.3684E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 1.5936328\text{E-}005$   
with  $f_y = 444.44$   
 $d = 207.00$   
 $y = 0.32636518$   
 $A = 0.02001809$   
 $B = 0.01213028$   
with  $p_t = 0.00801334$   
 $p_c = 0.00801334$   
 $p_v = 0.00388525$   
 $N = 4883.466$   
 $b = 500.00$   
 $\mu = 0.20772947$   
 $y_{\text{comp}} = 2.5390422\text{E-}005$   
with  $f_c = 20.00$   
 $E_c = 21019.039$   
 $y = 0.32587375$   
 $A = 0.01977419$   
 $B = 0.01202411$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

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

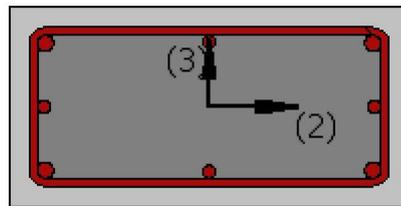
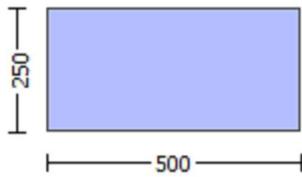
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 444.44$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.55$

#####  
 Section Height,  $H = 250.00$   
 Section Width,  $W = 500.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 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:  $A_{slt} = 0.00$   
 -Compression:  $A_{slc} = 2060.885$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl, \text{ten}} = 829.3805$   
 -Compression:  $A_{sl, \text{com}} = 829.3805$   
 -Middle:  $A_{sl, \text{mid}} = 402.1239$

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 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 the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  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, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00425603$

$w_e$  (5.4c) = 0.00035724

$a_{se}$  ((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 ((5.A5), TBDY), TBDY:  $\phi_c = 0.002$

$c$  = 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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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/d  
-----

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.00020406$$

$$\mu_u = 1.1226E+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00225456$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00425603$$

$$w_e \text{ (5.4c)} = 0.00035724$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.001496$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00299199$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

$$l_o/l_{ou,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

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.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = fs = 555.55$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

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  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 555.55$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_v = fs = 555.55$$

$$\text{with } Es_v = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.22259049$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.22259049$$

$$v = A_{sl,mid}/(b*d) * (fs_v/fc) = 0.10792266$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.29581556$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.29581556$$

$$v = A_{sl,mid}/(b*d) * (fs_v/fc) = 0.14342573$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.24243176$$

$$\mu_u = MR_c (4.14) = 1.1226E+008$$

$$u = su (4.1) = 0.00020406$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $\mu_{u2+}$

-----  
Calculation of ultimate curvature  $u$  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  
 fc = 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 =  $\text{Min}(\text{psh},x, \text{psh},y) = 0.001496$   
 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)

-----  
 psh,x (5.4d) = 0.001496  
 Ash =  $\text{Astir} * \text{ns} = 78.53982$   
 No stirrups, ns = 2.00  
 bk = 500.00

-----  
 psh,y (5.4d) = 0.00299199  
 Ash =  $\text{Astir} * \text{ns} = 78.53982$   
 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  
 $lo/lou,min = lb/d = 1.00$   
 $su1 = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $\text{esu1\_nominal} = 0.08$ ,  
 For calculation of  $\text{esu1\_nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $\text{fsy1} = \text{fs1}/1.2$ , 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  $\text{fs1} = \text{fs} = 555.55$   
 with  $\text{Es1} = \text{Es} = 200000.00$   
 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  
 $lo/lou,min = lb/lb,min = 1.00$   
 $su2 = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $\text{esu2\_nominal} = 0.08$ ,  
 For calculation of  $\text{esu2\_nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $\text{fsy2} = \text{fs2}/1.2$ , 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  $\text{fs2} = \text{fs} = 555.55$   
 with  $\text{Es2} = \text{Es} = 200000.00$   
 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:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 20.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.29581556$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.29581556$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.14342573$   
 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:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 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/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 = fs/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 = fs/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.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = f_s = 555.55$

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:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 20.00$

$cc \text{ (5A.5, TBDY)} = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.29581556$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.29581556$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.14342573$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

---

$\mu \text{ (4.9)} = 0.24243176$

$\mu_u = M_{Rc} \text{ (4.14)} = 1.1226E+008$

$u = \mu \text{ (4.1)} = 0.00020406$

-----  
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,  $V_{r1} = 112732.921$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Co10}$

$V_{Co10} = 112732.921$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $= 1$  (normal-weight concrete)

$f_c' = 20.00$ , but  $f_c'^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 1.3332753E-012$

$\mu_v = 7.2890426E-033$

$d = 0.8 \cdot h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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,  $V_{r2} = 112732.921$

$V_{r2} = V_{Co2} \text{ ((10.3), ASCE 41-17)} = k_{nl} \cdot V_{Co10}$

$V_{Co10} = 112732.921$

$k_{nl} = 1$  (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:  $As_{,ten} = 829.3805$

-Compression:  $As_{,com} = 829.3805$

-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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.8226E+008$

$M_{u2+} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.8226E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.2672130E-005$

$M_u = 2.8226E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00204242$

$N = 4666.932$

$f_c = 20.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00425603$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00425603$

$w_e$  (5.4c) = 0.00035724

$a_{se}$  ((5.4d), TBDY) = 0.02865579

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.001496$

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 ((5.A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00231479$   
 $sh_1 = 0.008$   
 $ft_1 = 666.66$   
 $fy_1 = 555.55$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \text{min} = lb/d = 1.00$   
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \text{min} = lb/lb, \text{min} = 1.00$   
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \text{min} = lb/d = 1.00$   
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = fs = 555.55$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.20164653$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.20164653$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.09776801$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 20.00$   
 $cc \text{ (5A.5, TBDY)} = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.28396544$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.28396544$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13768021$$

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  $u$  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)

$$p_{sh, x}(5.4d) = 0.001496$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00299199$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = fs = 555.55

with Esv = Es = 200000.00

1 = Asl,ten/(b\*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:  $l_b/d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2672130E-005$$

$$\mu = 2.8226E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00204242$$

$$N = 4666.932$$

$$f_c = 20.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00425603$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00425603$$

$$w_e \text{ (5.4c)} = 0.00035724$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.02865579$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.001496$$

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)

$$p_{sh,x} \text{ (5.4d)} = 0.001496$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} \text{ (5.4d)} = 0.00299199$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 210.00$$

$$f_{ywe} = 555.55$$

$$f_{ce} = 20.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00231479$$

$$sh_1 = 0.008$$

$$ft_1 = 666.66$$

$$fy_1 = 555.55$$

$$su_1 = 0.032$$

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

$$l_o/l_{o,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

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.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = fs = 555.55$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00231479$$

$$sh_2 = 0.008$$

$$ft_2 = 666.66$$

$$fy_2 = 555.55$$

$$su_2 = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = fs = 555.55$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00231479$$

$$sh_v = 0.008$$

$$ft_v = 666.66$$

$$fy_v = 555.55$$

$$suv = 0.032$$

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

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 555.55$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.20164653$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.20164653$$

$$v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (fs_1/fc) = 0.28396544$$

$$2 = A_{sl,com}/(b*d) * (fs_2/fc) = 0.28396544$$

$$v = A_{sl,mid}/(b*d) * (fsv/fc) = 0.13768021$$

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  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2672130E-005$$

$$Mu = 2.8226E+008$$

-----  
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:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00425603$   
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  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirrups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00299199  
Ash =  $\text{Astir} * ns = 78.53982$   
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  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , 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

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = fs = 555.55$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.20164653$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.20164653$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.09776801$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 20.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.28396544$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.28396544$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.13768021$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - 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,  $Vr1 = 245709.058$

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VCol0$$

$$VCol0 = 245709.058$$

$$knl = 1 \text{ (zero step-static loading)}$$

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 (normal-weight concrete)

$$fc' = 20.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 2.0649661E-012$$

$$Vu = 1.0640763E-031$$

$$d = 0.8 * h = 400.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14:  $V_s = 132976.137$

$$Av = 157079.633$$

$$fy = 444.44$$

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

-----  
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  $fc'^{0.5} <= 8.3$  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 ( $lb/d >= 1$ )  
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:  $A_{st} = 0.00$   
-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,  $DbL = 18.66667$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = \rho \cdot u = 0.03239699$   
 $u = \rho \cdot y + p = 0.03239699$

- Calculation of  $y$  -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00105998$  ((4.29), Biskinis Phd)  
 $M_y = 1.7406E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) =  $300.00$   
From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.6421E+013$   
factor =  $0.30$   
Ag =  $125000.00$   
fc' =  $20.00$   
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 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 6.9055145E-006$   
with  $f_y = 444.44$   
d =  $457.00$   
 $y = 0.29584073$   
A =  $0.01813455$   
B =  $0.009964$   
with  $p_t = 0.00725935$   
pc =  $0.00725935$   
pv =  $0.00351968$   
N =  $4883.466$   
b =  $250.00$   
" =  $0.0940919$   
 $y_{comp} = 1.2695211E-005$   
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  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.03133702$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/l_d \geq 1$   
shear control ratio  $V_{yE}/V_{CoIE} = 0.76584669$

$d = 457.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00299199$

$A_v = 157.0796$ , 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.

$NUD = 4883.466$

$Ag = 125000.00$

$f_{cE} = 20.00$

$f_{yE} = f_{yIE} = 444.44$

$\rho_l = \text{Area\_Tot\_Long\_Rein}/(b*d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 20.00$

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)