

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

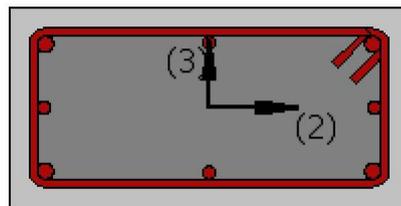
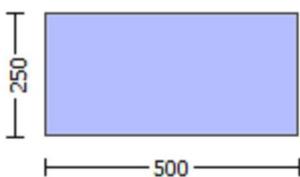
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

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

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

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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, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

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

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

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Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

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Stepwise Properties

EDGE -A-

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

Shear Force,  $V_a = -4751.50$

EDGE -B-

Bending Moment,  $M_b = -0.00088196$

Shear Force,  $V_b = 4751.50$

BOTH EDGES

Axial Force,  $F = -4665.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle:  $As_{mid} = 402.1239$

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

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

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

$V_{CoI} = 320061.918$

$k_n l = 1.00$

displacement\_ductility\_demand = 0.01896649

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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)

$M / Vd = 4.00$

$M_u = 1.4257E+007$

$V_u = 4751.50$

$d = 0.8 * h = 400.00$

$N_u = 4665.031$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

$V_s$  is multiplied by  $CoI = 1.00$

$s/d = 0.25$

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

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

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

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

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

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

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

Calculation of ratio  $I_b / I_d$

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

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

At local axis: 2

Integration Section: (a)

## Calculation No. 2

column C1, Floor 1

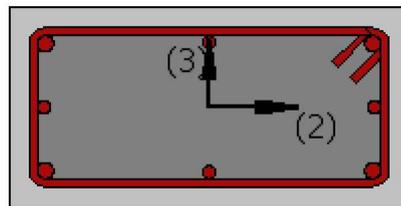
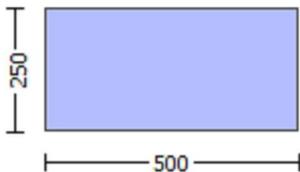
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

## Stepwise Properties

At local axis: 3

EDGE -A-

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

EDGE -B-

Shear Force,  $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle:  $As_{mid} = 402.1239$

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

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

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

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3221E+008$

$Mu_{1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3221E+008$

$Mu_{2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

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

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

$w_e$  (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

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

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

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

No stirups,  $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00  
fywe = 656.25  
fce = 30.00

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

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

and confined core properties:

b = 440.00  
d = 177.00  
d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 31.20058  
 $cc$  (5A.5, TBDY) = 0.00240019  
 $c$  = confinement factor = 1.04002  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $su$  (4.9) = 0.23279566  
 $Mu = MR_c$  (4.14) = 1.3221E+008  
 $u = su$  (4.1) = 0.0002015

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 Calculation of ratio  $l_b/l_d$

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 Adequate Lap Length:  $l_b/l_d \geq 1$   
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 Calculation of  $Mu_1$ -  
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 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 0.0002015$   
 $Mu = 1.3221E+008$

-----  
 with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00150304$   
 $N = 4666.932$   
 $f_c = 30.00$   
 $co$  (5A.5, TBDY) = 0.002  
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00595799$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00595799$   
 $w_e$  (5.4c) = 0.00377606  
 $ase$  ((5.4d), TBDY) = 0.05494666  
 $bo = 440.00$   
 $ho = 190.00$   
 $bi_2 = 459400.00$   
 $psh_{min} = Min(psh_x, psh_y) = 0.00314159$

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

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

-----  
 $s = 100.00$   
 $f_{ywe} = 656.25$   
 $f_{ce} = 30.00$   
 From ((5.A5), TBDY), TBDY:  $cc = 0.00240019$   
 $c$  = confinement factor = 1.04002  
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 787.50$   
 $fy_1 = 656.25$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

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

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.23295708

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.23295708

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.11294889

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

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

---

su (4.9) = 0.23279566

Mu = MRc (4.14) = 1.3221E+008

u = su (4.1) = 0.0002015

Calculation of ratio  $l_b/d$

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

Calculation of  $\mu_{2+}$

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

$\mu = 0.0002015$

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

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

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

Final value of  $\mu_c$ :  $\mu_c^* = \text{shear\_factor} * \text{Max}(\mu_c, \omega) = 0.00595799$

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

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

$\omega_e$  (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

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

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

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

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

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

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

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$su_1 = 0.4 * \omega_{su1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $\omega_{su1,nominal} = 0.08$ ,

For calculation of  $\omega_{su1,nominal}$  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  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $E_{s1} = E_s = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$$f_y2 = 656.25$$

$$s_u2 = 0.032$$

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

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

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$f_{y_v} = 656.25$$

$$s_{u_v} = 0.032$$

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

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

$$s_{u_v} = 0.4 * e_{su_v,nominal} ((5.5), TBDY) = 0.032$$

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

considering characteristic value  $f_{sy_v} = f_{sv}/1.2$ , 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  $f_{sv} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_y1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23279566$$

$$M_u = MR_c (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

-----  
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:

$$u = 0.0002015$$

$$M_u = 1.3221E+008$$

-----

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

---

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

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

No stirups,  $n_s = 2.00$

$$b_k = 500.00$$

---

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

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

No stirups,  $n_s = 2.00$

$$b_k = 250.00$$

---

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

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

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

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

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

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

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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.

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

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

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.17529176$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.17529176$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

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

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.23295708$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.23295708$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.23279566$$

$$Mu = MRc (4.14) = 1.3221E+008$$

$$u = su (4.1) = 0.0002015$$

-----  
Calculation of ratio  $lb/d$

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

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 302309.152$   
-----

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 302309.152$

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

$$VCol0 = 302309.152$$

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

-----  
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)

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

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } Vs = 164933.614$$

$$Av = 157079.633$$

$$fy = 525.00$$

$$s = 100.00$$

Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 302309.152  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 302309.152  
knl = 1 (zero step-static loading)

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

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.1816411E-012  
Vu = 7.3920505E-032  
d = 0.8\*h = 200.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 164933.614  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

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

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

Constant Properties

-----  
Knowledge Factor, = 0.85  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 656.25  
#####  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.04002  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel

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

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 4.5261760E-048$   
EDGE -B-  
Shear Force,  $V_b = -4.5261760E-048$   
BOTH EDGES  
Axial Force,  $F = -4666.932$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t, \text{ten}} = 829.3805$   
-Compression:  $As_{c, \text{com}} = 829.3805$   
-Middle:  $As_{c, \text{mid}} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.47299706$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.3151E+008$   
 $\mu_{1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $\mu_{1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.3151E+008$   
 $\mu_{2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $\mu_{2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $\mu_{1+}$   
-----

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

$$\mu = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00595799$$

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

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

$$\mu_{cc} (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

s = 100.00  
fywe = 656.25  
fce = 30.00

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

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

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.14815151$$

$$\mu_u = M R_c (4.14) = 3.3151E+008$$

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

Calculation of ratio  $l_b / l_d$

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

Calculation of  $\mu_{u1}$ -

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

$$u = 8.2199924E-005$$

$$\mu_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

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

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

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

c = confinement factor = 1.04002

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$su(4.9) = 0.14815151$$

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

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

-----  
Calculation of ratio  $lb/d$

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

-----  
Calculation of  $Mu_{2+}$

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

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

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

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

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

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

$$we(5.4c) = 0.00377606$$

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

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

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 500.00$$

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

$$Ash = Astir * ns = 78.53982$$

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

$$bk = 250.00$$

-----  
 $s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/d = 1.00$$

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

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

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

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

with  $f_{s1} = f_s = 656.25$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 787.50$   
 $fy_2 = 656.25$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{s2} = f_s = 656.25$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 787.50$   
 $fy_v = 656.25$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{sv} = f_s = 656.25$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = \text{confinement factor} = 1.04002$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14815151$   
 $Mu = MR_c (4.14) = 3.3151E+008$   
 $u = su (4.1) = 8.2199924E-005$

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

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

Calculation of  $Mu_2$ -  
 -----

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

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su_1 = 0.4 * \phi_{su1,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su1,nominal} = 0.08,$$

For calculation of  $\phi_{su1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_s/1.2$ , from table 5.1, TBDY.

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

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$su_2 = 0.4 * \phi_{su2,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su2,nominal} = 0.08,$$

For calculation of  $\phi_{su2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_s/1.2$ , from table 5.1, TBDY.

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

with  $fs_2 = fs = 656.25$

with  $Es_2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

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

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

Shear\_factor = 1.00

$lo/lou, \text{min} = lb/d = 1.00$

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

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

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

For calculation of  $esuv_{\text{nominal}}$  and  $yv, shv, ftv, fyv$ , it is considered

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

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

with  $fsv = fs = 656.25$

with  $Es_v = Es = 200000.00$

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15879823$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15879823$

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

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

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

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

c = confinement factor = 1.04002

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.22362502$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.22362502$

v =  $Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

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

---

$su (4.9) = 0.14815151$

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

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

-----  
Calculation of ratio  $lb/d$

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

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr_1, Vr_2) = 467242.766$   
-----

Calculation of Shear Strength at edge 1,  $Vr_1 = 467242.766$

$Vr_1 = VCoI ((10.3), \text{ASCE 41-17}) = knl \cdot VCoIO$

$VCoIO = 467242.766$

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

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

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

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

$M/Vd = 2.00$

$Mu = 3.6217549E-012$

$Vu = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$Nu = 4666.932$

Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 329867.229  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.25  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 250.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 467242.766  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 467242.766  
knl = 1 (zero step-static loading)

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

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 3.6217549E-012  
Vu = 4.5261760E-048  
d = 0.8\*h = 400.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 329867.229  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.25  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 250.00

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

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

At local axis: 2  
Integration Section: (a)  
Section Type: rcrs

Constant Properties

-----  
Knowledge Factor, = 0.85  
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel

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

-----  
Stepwise Properties  
-----

Bending Moment,  $M = 1.1221826E-009$   
Shear Force,  $V2 = -4751.50$   
Shear Force,  $V3 = -4.1317099E-013$   
Axial Force,  $F = -4665.031$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{s,ten} = 829.3805$   
-Compression:  $A_{s,com} = 829.3805$   
-Middle:  $A_{s,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $DbL = 18.66667$

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

-----  
- Calculation of  $y$  -  
-----

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

-----  
Calculation of Yielding Moment  $M_y$   
-----

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

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

Calculation of ratio  $l_b/d$

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

- Calculation of  $p$  -

From table 10-8:  $p = 0.00494605$

with:

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

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

$d = 207.00$

$s = 0.00$

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

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

$b_w = 500.00$

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

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

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

$N_{UD} = 4665.031$

$A_g = 125000.00$

$f_{cE} = 30.00$

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

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

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

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

At local axis: 2

Integration Section: (a)

### Calculation No. 3

column C1, Floor 1

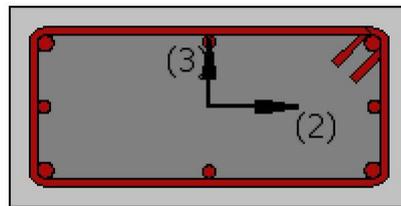
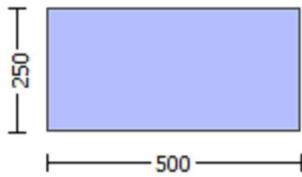
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

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

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

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

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

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 1.1221826E-009$

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

EDGE -B-

Bending Moment,  $M_b = 1.1815160E-010$

Shear Force,  $V_b = 4.1317099E-013$

BOTH EDGES

Axial Force,  $F = -4665.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{slc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 244283.162$   
 $V_n$  ((10.3), ASCE 41-17) =  $kn1 \cdot V_{Col0} = 244283.162$   
 $V_{Col} = 244283.162$   
 $kn1 = 1.00$   
 $displacement\_ductility\_demand = 0.00$

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

= 1 (normal-weight concrete)  
 $f_c' = 20.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $Mu = 1.1221826E-009$   
 $Vu = 4.1317099E-013$   
 $d = 0.8 \cdot h = 200.00$   
 $Nu = 4665.031$   
 $Ag = 125000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = 131946.891$   
 $A_v = 157079.633$   
 $f_y = 420.00$   
 $s = 100.00$   
 $V_s$  is multiplied by  $Col = 1.00$   
 $s/d = 0.50$   
 $V_f$  ((11-3)-(11.4), ACI 440) =  $0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 297085.704$   
 $bw = 500.00$

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

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

From analysis, chord rotation  $\phi = 5.8795680E-020$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00923028$  ((4.29), Biskinis Phd)  
 $M_y = 9.2818E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) =  $1500.00$   
From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$   
 $factor = 0.30$   
 $Ag = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.031$   
 $E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi / y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 1.8256816E-005$   
with  $f_y = 525.00$   
 $d = 207.00$   
 $y = 0.30540138$   
 $A = 0.01999778$   
 $B = 0.01210997$   
with  $pt = 0.00801334$   
 $pc = 0.00801334$   
 $pv = 0.00388525$   
 $N = 4665.031$

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

Calculation of ratio  $l_b/d$

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

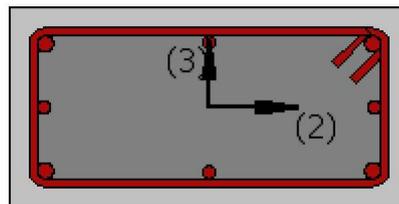
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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,  $\gamma = 0.85$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 3

EDGE -A-

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

EDGE -B-

Shear Force,  $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st, \text{ten}} = 829.3805$

-Compression:  $A_{st, \text{com}} = 829.3805$

-Middle:  $A_{st, \text{mid}} = 402.1239$

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

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

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

with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3221E+008$   
 $M_{u1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

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

$M_{u2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

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

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

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

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

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

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups,  $n_s = 2.00$

$$b_k = 500.00$$

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

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

No stirrups,  $n_s = 2.00$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$s_u_1 = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1\_nominal} = 0.08,$$

For calculation of  $e_{s1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_s/1.2$ , from table 5.1, TBDY.

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

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$s_u_2 = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2\_nominal} = 0.08,$$

For calculation of  $e_{s2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_s/1.2$ , from table 5.1, TBDY.

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

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

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

$$y_v = 0.0025$$

$shv = 0.008$   
 $ftv = 787.50$   
 $fyv = 656.25$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $fsv = fs = 656.25$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995$   
 and confined core properties:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = confinement\ factor = 1.04002$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < vs,c$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23279566$   
 $Mu = MRc (4.14) = 1.3221E+008$   
 $u = su (4.1) = 0.0002015$

-----  
 Calculation of ratio  $lb/ld$   
 -----

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

-----  
 Calculation of  $Mu1$ -  
 -----

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

$u = 0.0002015$   
 $Mu = 1.3221E+008$   
 -----

with full section properties:

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

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

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

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

s = 100.00  
fywe = 656.25  
fce = 30.00  
From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002  
y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with  $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23279566$$

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

$$u = s_u (4.1) = 0.0002015$$

-----  
Calculation of ratio  $l_b/d$

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

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

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

$$u = 0.0002015$$

$$\mu_u = 1.3221E+008$$

-----  
with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

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

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

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

From (5.A.5), TBDY, TBDY:  $cc = 0.00240019$

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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, ASCE41-17.

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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, ASCE41-17.

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

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

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.17529176$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.17529176$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

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

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

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.23295708$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.23295708$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.11294889$$

Case/Assumption: Unconfinedsd full section - Steel rupture

does not satisfy Eq. (4.3)

--->

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

--->

$\mu_u$  (4.9) = 0.23279566

$\mu_u = M/R_c$  (4.14) = 1.3221E+008

$u = \mu_u$  (4.1) = 0.0002015

-----  
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:

$u = 0.0002015$

$\mu_u = 1.3221E+008$

-----  
with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

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

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

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

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

$w_e$  (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

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

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

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

No stirups,  $n_s = 2.00$

$b_k = 500.00$

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

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

No stirups,  $n_s = 2.00$

$b_k = 250.00$

-----  
 $s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

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

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

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$\mu_{s1} = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$\mu_{s1} = 0.4 * \mu_{s1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $\mu_{s1,nominal} = 0.08$ ,

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

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

with  $fs1 = fs = 656.25$

with  $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 787.50$

$fy2 = 656.25$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

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

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

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

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

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

with  $fs2 = fs = 656.25$

with  $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

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

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

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

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

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

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

with  $fsv = fs = 656.25$

with  $Esv = Es = 200000.00$

1 =  $Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.17529176$

2 =  $Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.17529176$

v =  $Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08498995$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 31.20058

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

$c$  = confinement factor = 1.04002

1 =  $Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.23295708$

2 =  $Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.23295708$

v =  $Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11294889$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.23279566

$Mu = MRc$  (4.14) = 1.3221E+008

$u = su$  (4.1) = 0.0002015

-----  
Calculation of ratio  $lb/ld$

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

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

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

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

$V_{Co10} = 302309.152$

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

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

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

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

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.50$

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

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

$b_w = 500.00$   
-----

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

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

$V_{Co10} = 302309.152$

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

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

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

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

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.50$

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

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

$b_w = 500.00$   
-----

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

At local axis: 3  
-----

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\phi = 0.85$

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = 4.5261760E-048$

EDGE -B-

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

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

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

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

with

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

$M_{u1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

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

$M_{u2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

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

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

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

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

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered

characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{s2} = f_s = 656.25$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$f_{yv} = 656.25$

$s_{uv} = 0.032$

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

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

Shear\_factor = 1.00

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

$s_{uv} = 0.4 \cdot e_{suv,nominal} ((5.5), TBDY) = 0.032$

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

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{sv} = f_s = 656.25$

with  $E_{sv} = E_s = 200000.00$

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

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

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

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

f<sub>cc</sub> (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

$s_u$  (4.9) = 0.14815151

$\mu_u = MR_c$  (4.14) = 3.3151E+008

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

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

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

-----  
Calculation of  $\mu_{u1}$ -

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

u = 8.2199924E-005

$\mu_u = 3.3151E+008$

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

f<sub>c</sub> = 30.00

c<sub>o</sub> (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00595799$

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

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

$w_e$  (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

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

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

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

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

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

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

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

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

$c =$  confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with  $fs_1 = fs = 656.25$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$fy_2 = 656.25$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

$su_2 = 0.4 * esu_2_{nominal}$  ((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.

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

with  $fs_2 = fs = 656.25$

with  $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{sv\_nominal}$  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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{sv} = f_s = 656.25$

with  $E_{sv} = E_s = 200000.00$

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

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

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

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

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

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/ld

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

-----  
Calculation of Mu2+

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

u = 8.2199924E-005

Mu = 3.3151E+008

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

$f_c$  = 30.00

co (5A.5, TBDY) = 0.002

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

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

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

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

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

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

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

No stirrups,  $n_s = 2.00$

bk = 500.00

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

Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00  
d = 427.00  
d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $Asl_{ten}/(b*d)*(fs1/fc) = 0.22362502$

2 =  $Asl_{com}/(b*d)*(fs2/fc) = 0.22362502$

v =  $Asl_{mid}/(b*d)*(fsv/fc) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < v<sub>s,c</sub> - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----  
Calculation of Mu<sub>2</sub>-

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

u = 8.2199924E-005

Mu = 3.3151E+008

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

fc = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00595799

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

From (5.4b), TBDY: cu = 0.00595799

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

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

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

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

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

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

-----  
s = 100.00

fywe = 656.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

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

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

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

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

Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

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

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

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

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

--->

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/d

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

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

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

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

$V_{Col0} = 467242.766$

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

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

= 1 (normal-weight concrete)

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

$M/d = 2.00$

$M_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.25$

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

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

$b_w = 250.00$

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

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

$V_{Col0} = 467242.766$

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

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

= 1 (normal-weight concrete)

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

$M/d = 2.00$

$M_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.25$

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

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

$b_w = 250.00$

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

At local axis: 2

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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

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

Consequently:

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

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

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $b/d > 1$ )

No FRP Wrapping

Stepwise Properties

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

Shear Force,  $V_2 = -4751.50$

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

Axial Force,  $F = -4665.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-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,  $DbL = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = 1.0^*$   $\phi_u = 0.01491271$

$\phi_u = \phi_y + \phi_p = 0.01491271$

- Calculation of  $\phi_y$  -

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

$M_y = 2.0703E+008$

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

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

factor = 0.30

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.031$

$E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

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

Calculation of ratio  $l_b/d$

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

- Calculation of  $\rho$  -

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

with:

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

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

$d = 457.00$

$s = 0.00$

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

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

$b_w = 250.00$

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

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

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

$N_{UD} = 4665.031$

$A_g = 125000.00$

$f_{cE} = 30.00$

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

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

$b = 250.00$

$d = 457.00$

$f_{cE} = 30.00$

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

At local axis: 3

Integration Section: (a)

## Calculation No. 5

column C1, Floor 1

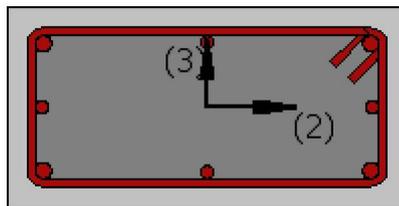
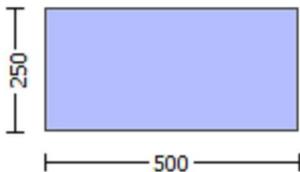
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

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

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

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

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

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

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

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

Shear Force,  $V_a = -4751.50$

EDGE -B-

Bending Moment,  $M_b = -0.00088196$

Shear Force,  $V_b = 4751.50$

BOTH EDGES

Axial Force,  $F = -4665.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle:  $As_{mid} = 402.1239$

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

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

$V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI} = 376230.054$

$V_{CoI} = 376230.054$

$k_n = 1.00$

$displacement\_ductility\_demand = 0.10328958$

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)

$M/Vd = 2.00$

$M_u = 0.00088196$

$V_u = 4751.50$

$d = 0.8 * h = 400.00$

$N_u = 4665.031$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.25$

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

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

$bw = 250.00$

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

- Calculation of  $\phi / y$  for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation =  $0.00010632$

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

$M_y = 2.0703E+008$

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

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

$factor = 0.30$

$A_g = 125000.00$

$f_c' = 30.00$

N = 4665.031  
Ec\*Ig = 6.7039E+013

Calculation of Yielding Moment My

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

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

Calculation of ratio lb/d

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

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

## Calculation No. 6

column C1, Floor 1

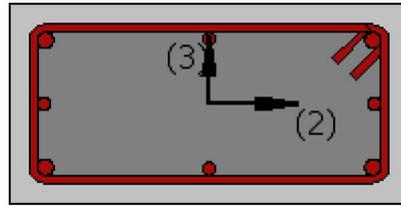
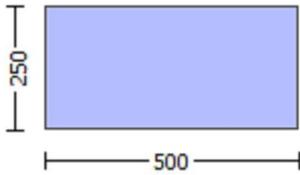
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta_u$  )

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,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$   
 Concrete Elasticity,  $E_c = 25742.96$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

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

-----  
 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -7.3920505E-032$   
 EDGE -B-  
 Shear Force,  $V_b = 7.3920505E-032$   
 BOTH EDGES  
 Axial Force,  $F = -4666.932$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl, t} = 0.00$   
 -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 ,  $V_e/V_r = 0.29154496$

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

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

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

$M_{u1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

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

$M_{u2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

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

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

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$   
-----

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

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

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

$w_e$  (5.4c) = 0.00377606

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

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

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

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

No stirups,  $n_s = 2.00$

$b_k = 500.00$   
-----

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

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

No stirups,  $n_s = 2.00$

$b_k = 250.00$   
-----

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

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

$c$  = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

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

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

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

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

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

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

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

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

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

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

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

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

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

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

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

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

$$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.23295708$$

$$2 = Asl, com / (b * d) * (fs2 / fc) = 0.23295708$$

$$v = Asl, mid / (b * d) * (fsv / fc) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

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

---

$$su (4.9) = 0.23279566$$

$$Mu = MRc (4.14) = 1.3221E+008$$

$$u = su (4.1) = 0.0002015$$

Calculation of ratio  $lb/ld$

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

Calculation of Mu1-

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

$$\mu = 0.0002015$$

$$\text{Mu} = 1.3221\text{E}+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

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

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

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

$$b_k = 500.00$$

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

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

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

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

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

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$s_u2 = 0.4 * e_{su2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{su2\_nominal} = 0.08$ ,

For calculation of  $e_{su2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

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

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

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$s_{uv} = 0.032$$

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

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

$$s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$$

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

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv\_nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.23279566$$

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

$$u = s_u (4.1) = 0.0002015$$

-----  
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:

$$u = 0.0002015$$

$$\mu_u = 1.3221E+008$$

-----  
with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

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

-----  
psh,x (5.4d) = 0.00314159  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirups, ns = 2.00  
bk = 500.00

-----  
psh,y (5.4d) = 0.00628319  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirups, ns = 2.00  
bk = 250.00

-----  
s = 100.00  
fywe = 656.25  
fce = 30.00  
From ((5.A5), TBDY), TBDY:  $cc = 0.00240019$   
c = confinement factor = 1.04002  
y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min =  $lb/ld = 1.00$   
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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
with  $fs1 = fs = 656.25$   
with  $Es1 = Es = 200000.00$

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min =  $lb/lb,min = 1.00$   
su2 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$   
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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
with  $fs2 = fs = 656.25$   
with  $Es2 = Es = 200000.00$

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_d = 1.00$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $\gamma_v$ ,  $sh_v, ft_v, fy_v$ , 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  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{sv} = f_s = 656.25$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.17529176$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.17529176$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08498995$

and confined core properties:

$b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = \text{confinement factor} = 1.04002$   
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.23295708$   
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.23295708$   
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.11294889$

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

--->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $s_u (4.9) = 0.23279566$   
 $M_u = M_{Rc} (4.14) = 1.3221E+008$   
 $u = s_u (4.1) = 0.0002015$

Calculation of ratio  $l_b/l_d$

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

Calculation of  $M_{u2}$ -

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

$u = 0.0002015$   
 $M_u = 1.3221E+008$

with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00150304$   
 $N = 4666.932$   
 $f_c = 30.00$   
 $cc (5A.5, TBDY) = 0.002$   
 Final value of  $\phi_u$ :  $\phi_u * = \text{shear\_factor} * \text{Max}(\phi_{cu}, cc) = 0.00595799$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\phi_{cu} = 0.00595799$   
 $w_e (5.4c) = 0.00377606$   
 $a_{se} ((5.4d), TBDY) = 0.05494666$   
 $bo = 440.00$   
 $ho = 190.00$   
 $bi_2 = 459400.00$   
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

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

No stirrups, ns = 2.00  
bk = 500.00

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

s = 100.00  
fywe = 656.25  
fce = 30.00

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

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

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

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

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

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

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

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

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

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 656.25

with Esv = Es = 200000.00

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

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

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

and confined core properties:

b = 440.00

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$$

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

--->

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

--->

$$s_u (4.9) = 0.23279566$$

$$\mu = MR_c (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

Calculation of ratio  $l_b/d$

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

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

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

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

$$V_{Col0} = 302309.152$$

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

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

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

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

$$M/Vd = 2.00$$

$$\mu_u = 6.1816411E-012$$

$$V_u = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 164933.614$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

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

$$s/d = 0.50$$

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

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

$$b_w = 500.00$$

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

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

$$V_{Col0} = 302309.152$$

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

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$\mu_u = 6.1816411E-012$$

$$V_u = 7.3920505E-032$$

d = 0.8\*h = 200.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 164933.614  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcrs

Constant Properties

-----  
Knowledge Factor, = 0.85  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 656.25  
#####  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.04002  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length (lo/lo<sub>u</sub>, min >= 1)  
No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = 4.5261760E-048  
EDGE -B-  
Shear Force, Vb = -4.5261760E-048  
BOTH EDGES  
Axial Force, F = -4666.932  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: As<sub>t</sub> = 0.00  
-Compression: As<sub>c</sub> = 2060.885  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: As<sub>t,ten</sub> = 829.3805

-Compression:  $A_{sl,com} = 829.3805$   
-Middle:  $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.47299706$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3151E+008$

$M_{u1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3151E+008$

$M_{u2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.2199924E-005$

$M_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

$\phi_{co}$  (5A.5, TBDY) = 0.002

Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_{cu} = 0.00595799$

$\phi_{we}$  (5.4c) = 0.00377606

$\phi_{ase}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

$\phi_{psh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 500.00$

$\phi_{psh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A.5), TBDY), TBDY:  $\phi_{cc} = 0.00240019$

$c$  = confinement factor = 1.04002

$\gamma_1 = 0.0025$

$\gamma_{sh1} = 0.008$

$f_{t1} = 787.50$

$f_{y1} = 656.25$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < vs,c - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_1$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.2199924E-005$

$\mu_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.00595799$

$\mu_w$  (5.4c) = 0.00377606

$\alpha_{se}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00314159$

$\mu_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

$\mu_{sh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\mu_c = 0.00240019$

$c$  = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{u1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $\mu_{u1\_nominal} = 0.08$ ,

For calculation of  $\mu_{u1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fs_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$$f_y2 = 656.25$$

$$s_u2 = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } f_{s2} = f_s = 656.25$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$f_{y_v} = 656.25$$

$$s_{u_v} = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{su_v,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{su_v,nominal} = 0.08$ ,

considering characteristic value  $f_{sy_v} = f_{sv}/1.2$ , 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  $f_{sy_v} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $M_{u2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

-----

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_c (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_c: \phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_c = 0.00595799$$

$$\phi_w (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00314159$$

---

$$\phi_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

---

$$\phi_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

---

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{nominal} = 0.08,$$

For calculation of esu1\_nominal and 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 \* (l\_b/l\_d)^{2/3}), from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu2_{nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{nominal} = 0.08,$$

For calculation of esu2\_nominal and 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 \* (l\_b/l\_d)^{2/3}), from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$f_{tv} = 787.50$$

$$f_{yv} = 656.25$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $\gamma_v$ ,  $sh_v, f_{tv}, f_{yv}$ , it is considered  
characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$\gamma_1$ ,  $sh_1, f_{t1}, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio  $l_b/l_d$

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:

$$u = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

bi2 = 459400.00  
psh,min = Min(psh,x , psh,y) = 0.00314159

psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1,  $V_{r1} = 467242.766$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f'_c = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/d = 2.00$$

$$M_u = 3.6217549E-012$$

$$V_u = 4.5261760E-048$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 329867.229$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

$V_s$  is multiplied by  $Col = 1.00$

$$s/d = 0.25$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 363854.192$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 467242.766$

$$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
 $f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 3.6217549E-012$   
 $V_u = 4.5261760E-048$   
 $d = 0.8 \cdot h = 400.00$   
 $N_u = 4666.932$   
 $A_g = 125000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = 329867.229$   
 $A_v = 157079.633$   
 $f_y = 525.00$   
 $s = 100.00$   
 $V_s$  is multiplied by  $Col = 1.00$   
 $s/d = 0.25$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$   
 $b_w = 250.00$

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1  
At local axis: 2  
Integration Section: (b)  
Section Type: rcrs

#### Constant Properties

-----  
Knowledge Factor,  $\phi = 0.85$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$   
Concrete Elasticity,  $E_c = 25742.96$   
Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 250.00$   
Section Width,  $W = 500.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Primary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d > 1$ )  
No FRP Wrapping

#### Stepwise Properties

-----  
Bending Moment,  $M = 1.1815160E-010$   
Shear Force,  $V_2 = 4751.50$   
Shear Force,  $V_3 = 4.1317099E-013$   
Axial Force,  $F = -4665.031$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-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,  $D_{bL} = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = 1.0$   $\phi_u = 0.01417633$   
 $\phi_u = \phi_y + \phi_p = 0.01417633$

- Calculation of  $\phi_y$  -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00923028$  ((4.29), Biskinis Phd))  
 $M_y = 9.2818E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 5.0279E+012$   
factor = 0.30  
 $A_g = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.031$   
 $E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

$\phi_y = \text{Min}(\phi_{y\_ten}, \phi_{y\_com})$   
 $\phi_{y\_ten} = 1.8256816E-005$   
with  $f_y = 525.00$   
 $d = 207.00$   
 $\phi_y = 0.30540138$   
 $A = 0.01999778$   
 $B = 0.01210997$   
with  $p_t = 0.00801334$   
 $p_c = 0.00801334$   
 $p_v = 0.00388525$   
 $N = 4665.031$   
 $b = 500.00$   
 $\phi_{y\_com} = 3.3230737E-005$   
with  $f_c = 30.00$   
 $E_c = 25742.96$   
 $\phi_y = 0.30494742$   
 $A = 0.01980449$   
 $B = 0.01202411$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $\phi_p$  -

From table 10-8:  $\phi_p = 0.00494605$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.29154496$

$d = 207.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$b_w = 500.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

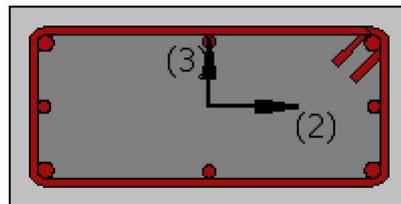
All these variables have already been given in Shear control ratio calculation.

NUD = 4665.031  
Ag = 125000.00  
fcE = 30.00  
fytE = fylE = 0.00  
pl = Area\_Tot\_Long\_Rein/(b\*d) = 0.01991193  
b = 500.00  
d = 207.00  
fcE = 30.00

-----  
End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1  
At local axis: 2  
Integration Section: (b)  
-----

## Calculation No. 7

column C1, Floor 1  
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity VRd  
Edge: End  
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcrs

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material: Steel Strength,  $f_s = f_{sm} = 525.00$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 1.1221826E-009$

Shear Force,  $V_a = -4.1317099E-013$

EDGE -B-

Bending Moment,  $M_b = 1.1815160E-010$

Shear Force,  $V_b = 4.1317099E-013$

BOTH EDGES

Axial Force,  $F = -4665.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-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,  $Db_{L,ten} = 18.66667$

-----  
New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 244283.162$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 244283.162$

$V_{CoI} = 244283.162$

$k_n = 1.00$

displacement\_ductility\_demand = 0.00

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

$f_c' = 20.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 1.1815160E-010$

$V_u = 4.1317099E-013$

$d = 0.8 \cdot h = 200.00$

$N_u = 4665.031$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 131946.891$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

$V_s$  is multiplied by  $CoI = 1.00$

$s/d = 0.50$

Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 297085.704  
bw = 500.00

displacement\_ductility\_demand is calculated as  $\phi_y$

- Calculation of  $\phi_y$  for END B -  
for rotation axis 2 and integ. section (b)

From analysis, chord rotation = 2.6253864E-020  
 $y = (M_y * L_s / 3) / E_{eff} = 0.00923028$  ((4.29), Biskinis Phd)  
My = 9.2818E+007  
Ls = M/V (with Ls > 0.1\*L and Ls < 2\*L) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 5.0279E+012$   
factor = 0.30  
Ag = 125000.00  
fc' = 30.00  
N = 4665.031  
Ec\*Ig = 1.6760E+013

Calculation of Yielding Moment My

Calculation of  $\phi_y$  and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
y\_ten = 1.8256816E-005  
with fy = 525.00  
d = 207.00  
y = 0.30540138  
A = 0.01999778  
B = 0.01210997  
with pt = 0.00801334  
pc = 0.00801334  
pv = 0.00388525  
N = 4665.031  
b = 500.00  
" = 0.20772947  
y\_comp = 3.3230737E-005  
with fc = 30.00  
Ec = 25742.96  
y = 0.30494742  
A = 0.01980449  
B = 0.01202411  
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)

## Calculation No. 8

column C1, Floor 1

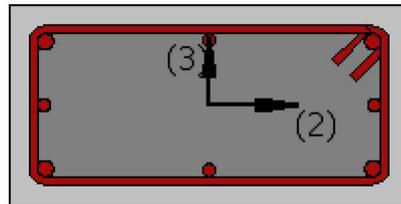
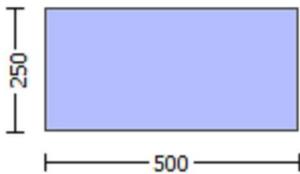
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )

No FRP Wrapping

## Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -7.3920505E-032$

EDGE -B-

Shear Force,  $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 829.3805$

-Compression:  $As_{c,com} = 829.3805$

-Middle:  $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.29154496$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3221E+008$

$Mu_{1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3221E+008$

$Mu_{2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00595799$

$w_e$  (5.4c) = 0.00377606

$a_{se}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00314159$

$\phi_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/b,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, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.17529176

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.17529176

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00  
d = 177.00  
d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 31.20058  
 $c_c$  (5A.5, TBDY) = 0.00240019  
 $c$  = confinement factor = 1.04002  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $s_u$  (4.9) = 0.23279566  
 $\mu_u = M R_c$  (4.14) = 1.3221E+008  
 $u = s_u$  (4.1) = 0.0002015

-----  
 Calculation of ratio  $l_b/l_d$

-----  
 Adequate Lap Length:  $l_b/l_d \geq 1$   
 -----  
 -----

-----  
 Calculation of  $\mu_{u1}$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 0.0002015$   
 $\mu_u = 1.3221E+008$

-----  
 with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00150304$   
 $N = 4666.932$   
 $f_c = 30.00$   
 $c_o$  (5A.5, TBDY) = 0.002  
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.00595799$   
 $w_e$  (5.4c) = 0.00377606  
 $a_{se}$  ((5.4d), TBDY) = 0.05494666  
 $b_o = 440.00$   
 $h_o = 190.00$   
 $b_{i2} = 459400.00$   
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

-----  
 $p_{sh,x}$  (5.4d) = 0.00314159  
 $A_{sh} = A_{stir} * n_s = 78.53982$   
 No stirups,  $n_s = 2.00$   
 $b_k = 500.00$

-----  
 $p_{sh,y}$  (5.4d) = 0.00628319  
 $A_{sh} = A_{stir} * n_s = 78.53982$   
 No stirups,  $n_s = 2.00$   
 $b_k = 250.00$

-----  
 $s = 100.00$   
 $f_{ywe} = 656.25$   
 $f_{ce} = 30.00$   
 From ((5.A5), TBDY), TBDY:  $c_c = 0.00240019$   
 $c$  = confinement factor = 1.04002  
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 787.50$   
 $fy_1 = 656.25$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.17529176

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.17529176

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.23295708

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.23295708

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.11294889

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < vs,c - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.23279566

Mu = MRc (4.14) = 1.3221E+008

u = su (4.1) = 0.0002015

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 0.0002015$

$\mu_{2+} = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu_c$ :  $\mu_c^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.00595799$

$\mu_{we}$  (5.4c) = 0.00377606

$\mu_{ase}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00314159$

$\mu_{psh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

$\mu_{psh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\mu_{cc} = 0.00240019$

$c$  = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{es1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $\mu_{es1\_nominal} = 0.08$ ,

For calculation of  $\mu_{es1\_nominal}$  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  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $E_{s1} = E_s = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$$f_y2 = 656.25$$

$$s_u2 = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } f_{s2} = f_s = 656.25$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$f_{y_v} = 656.25$$

$$s_{u_v} = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $y_v$ ,  $sh_v, ft_v, f_{y_v}$ , it is considered  
characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23279566$$

$$M_u = M_{Rc} (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $M_{u2}$ -

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.0002015$$

$$M_u = 1.3221E+008$$

-----

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_c (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_c: \phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_c = 0.00595799$$

$$\phi_w (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{sh, \min} = \text{Min}(\phi_{sh, x}, \phi_{sh, y}) = 0.00314159$$

---

$$\phi_{sh, x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

---

$$\phi_{sh, y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

---

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o, \min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu1_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

For calculation of  $esu1_{\text{nominal}}$  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  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o, \min} = l_b/l_{b, \min} = 1.00$$

$$su_2 = 0.4 * esu2_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

For calculation of  $esu2_{\text{nominal}}$  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.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

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.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.17529176$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.17529176$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.23295708$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.23295708$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.23279566$$

$$Mu = MRc (4.14) = 1.3221E+008$$

$$u = su (4.1) = 0.0002015$$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 302309.152$   
-----

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 302309.152$

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VCol0$$

$$VCol0 = 302309.152$$

$$knl = 1 \text{ (zero step-static loading)}$$

-----  
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)

$$fc' = 30.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14:  $Vs = 164933.614$

$$Av = 157079.633$$

$$fy = 525.00$$

$$s = 100.00$$

Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 302309.152  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 302309.152  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*VF'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.1816411E-012  
Vu = 7.3920505E-032  
d = 0.8\*h = 200.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 164933.614  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcrs

#### Constant Properties

-----  
Knowledge Factor, = 0.85  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 656.25  
#####  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.04002  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou, \min} \geq 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 4.5261760E-048$   
EDGE -B-  
Shear Force,  $V_b = -4.5261760E-048$   
BOTH EDGES  
Axial Force,  $F = -4666.932$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t, \text{ten}} = 829.3805$   
-Compression:  $As_{c, \text{com}} = 829.3805$   
-Middle:  $As_{c, \text{mid}} = 402.1239$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.47299706$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 3.3151E+008$   
 $\mu_{1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $\mu_{1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 3.3151E+008$   
 $\mu_{2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $\mu_{2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $\mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.00595799$$

$$\mu_{we} (5.4c) = 0.00377606$$

$$\mu_{ase} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{psh, \min} = \text{Min}(\mu_{psh, x}, \mu_{psh, y}) = 0.00314159$$

psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y2, sh2,ft2,fy2, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $M_u1$ -

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

c = confinement factor = 1.04002

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

$$su(4.9) = 0.14815151$$

$$Mu = MRc(4.14) = 3.3151E+008$$

$$u = su(4.1) = 8.2199924E-005$$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$

-----  
Calculation of  $Mu_{2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

$$co(5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$we(5.4c) = 0.00377606$$

$$ase((5.4d), TBDY) = 0.05494666$$

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

$$psh, \min = \text{Min}(psh, x, psh, y) = 0.00314159$$

-----  
 $psh, x(5.4d) = 0.00314159$

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 500.00$$

-----  
 $psh, y(5.4d) = 0.00628319$

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 250.00$$

-----  
 $s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/d = 1.00$$

$$su1 = 0.4 * esu1\_nominal((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08,$$

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{s1} = f_s = 656.25$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 787.50$   
 $fy_2 = 656.25$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_{b,min} = 1.00$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 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  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{s2} = f_s = 656.25$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 787.50$   
 $fy_v = 656.25$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{sv} = f_s = 656.25$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = \text{confinement factor} = 1.04002$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14815151$   
 $Mu = MR_c (4.14) = 3.3151E+008$   
 $u = su (4.1) = 8.2199924E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Adequate Lap Length:  $l_b/l_d \geq 1$   
 -----  
 -----  
 -----

Calculation of  $Mu_2$ -  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we}(5.4c) = 0.00377606$$

$$\phi_{ase}((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$$

$$\phi_{psh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$\phi_{psh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \phi_{su1\_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su1\_nominal} = 0.08,$$

For calculation of  $\phi_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{s1} = f_s = 656.25$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * \phi_{su2\_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su2\_nominal} = 0.08,$$

For calculation of  $\phi_{su2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_2 = fs = 656.25$

with  $Es_2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou, \text{min} = lb/d = 1.00$

$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $esuv_{\text{nominal}} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{\text{nominal}}$  and  $yv, shv, ftv, fyv$ , it is considered

characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fsv = fs = 656.25$

with  $Es_v = Es = 200000.00$

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15879823$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15879823$

v =  $Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07699308$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

$fcc (5A.2, \text{TBDY}) = 31.20058$

$cc (5A.5, \text{TBDY}) = 0.00240019$

c = confinement factor = 1.04002

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.22362502$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.22362502$

v =  $Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14815151$

$Mu = MRc (4.14) = 3.3151E+008$

$u = su (4.1) = 8.2199924E-005$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr_1, Vr_2) = 467242.766$   
-----

Calculation of Shear Strength at edge 1,  $Vr_1 = 467242.766$

$Vr_1 = V_{CoI} ((10.3), \text{ASCE 41-17}) = knl \cdot V_{CoI0}$

$V_{CoI0} = 467242.766$

$knl = 1$  (zero step-static loading)  
-----

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

$fc' = 30.00$ , but  $fc'^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 3.6217549E-012$

$Vu = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$Nu = 4666.932$

Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 329867.229  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.25  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 467242.766  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 467242.766  
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
fc' = 30.00, but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 3.6217549E-012  
Vu = 4.5261760E-048  
d = 0.8\*h = 400.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 329867.229  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.25  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 3  
Integration Section: (b)  
Section Type: rcrs

Constant Properties

Knowledge Factor,  $\phi = 0.85$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$   
Concrete Elasticity,  $E_c = 25742.96$   
Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 250.00$   
Section Width,  $W = 500.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Primary Member  
Smooth Bars  
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/d \geq 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

Bending Moment,  $M = -0.00088196$   
Shear Force,  $V2 = 4751.50$   
Shear Force,  $V3 = 4.1317099E-013$   
Axial Force,  $F = -4665.031$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 829.3805$   
-Compression:  $As_{c,com} = 829.3805$   
-Middle:  $As_{c,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $Db_L = 18.66667$

-----  
New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.0056463$   
 $u = y + p = 0.0056463$

-----  
- Calculation of  $y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00102938$  ((4.29), Biskinis Phd))  
 $M_y = 2.0703E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 300.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 2.0112E+013$   
factor = 0.30  
 $A_g = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.031$   
 $E_c * I_g = 6.7039E+013$

-----  
Calculation of Yielding Moment  $M_y$   
-----

Calculation of  $y$  and  $M_y$  according to Annex 7 -  
-----

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 7.9424731E-006$   
with  $f_y = 525.00$   
 $d = 457.00$   
 $y = 0.27680176$   
 $A = 0.01811615$   
 $B = 0.0099456$   
with  $p_t = 0.00725935$   
 $p_c = 0.00725935$   
 $p_v = 0.00351968$   
 $N = 4665.031$   
 $b = 250.00$   
 $" = 0.0940919$   
 $y_{comp} = 1.6615368E-005$   
with  $f_c = 30.00$   
 $E_c = 25742.96$   
 $y = 0.27625433$   
 $A = 0.01794105$   
 $B = 0.00986782$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00461692$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.47299706$

$d = 457.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$b_w = 250.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4665.031$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{ytE} = f_{ylE} = 0.00$

$p_l = \text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)

## Calculation No. 9

column C1, Floor 1

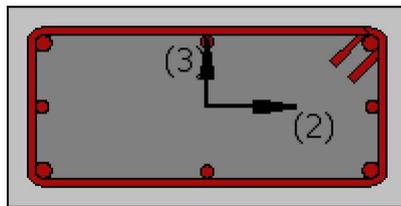
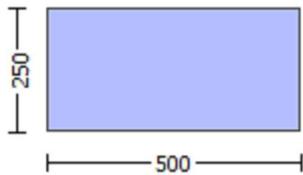
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material: Steel Strength,  $f_s = f_{sm} = 525.00$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -9.0404E+006$

Shear Force,  $V_a = -3012.903$

EDGE -B-

Bending Moment,  $M_b = -0.00055925$

Shear Force,  $V_b = 3012.903$

BOTH EDGES

Axial Force,  $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-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,  $Db_{L,ten} = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 320061.987$   
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 320061.987$   
 $V_{Col} = 320061.987$   
 $knl = 1.00$   
 $displacement\_ductility\_demand = 0.01202655$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$  (normal-weight concrete)  
 $f_c' = 20.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $M_u = 9.0404E+006$   
 $V_u = 3012.903$   
 $d = 0.8 \cdot h = 400.00$   
 $N_u = 4665.726$   
 $A_g = 125000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = 263893.783$   
 $A_v = 157079.633$   
 $f_y = 420.00$   
 $s = 100.00$   
 $V_s$  is multiplied by  $Col = 1.00$   
 $s/d = 0.25$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 297085.704$   
 $b_w = 250.00$

$displacement\_ductility\_demand$  is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END A -  
for rotation axis 3 and integ. section (a)

From analysis, chord rotation  $\phi = 0.00012382$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.01029579$  ((4.29), Biskinis Phd))  
 $M_y = 2.0703E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3000.571  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 2.0112E+013$   
 $factor = 0.30$   
 $A_g = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.726$   
 $E_c \cdot I_g = 6.7039E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 7.9424748E-006$   
with  $f_y = 525.00$   
 $d = 457.00$   
 $y = 0.27680192$   
 $A = 0.01811617$   
 $B = 0.00994561$   
with  $pt = 0.00725935$   
 $pc = 0.00725935$   
 $pv = 0.00351968$   
 $N = 4665.726$

b = 250.00  
" = 0.0940919  
y\_comp = 1.6615364E-005  
with fc = 30.00  
Ec = 25742.96  
y = 0.27625441  
A = 0.01794104  
B = 0.00986782  
with Es = 200000.00

Calculation of ratio 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: (a)

## Calculation No. 10

column C1, Floor 1

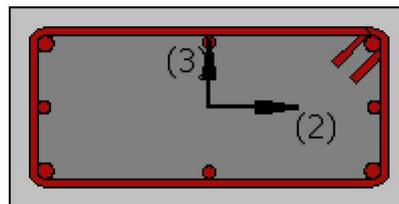
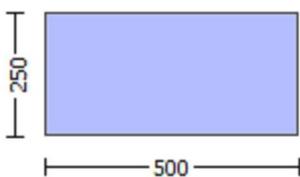
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( 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, = 0.85

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, \min} > 1$ )

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 3

EDGE -A-

Shear Force,  $V_a = -7.3920505E-032$

EDGE -B-

Shear Force,  $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st, \text{ten}} = 829.3805$

-Compression:  $A_{st, \text{com}} = 829.3805$

-Middle:  $A_{st, \text{mid}} = 402.1239$

-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.29154496$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$

with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3221E+008$   
 $M_{u1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3221E+008$

$M_{u2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e(5.4c) = 0.00377606$$

$$a_{se}((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 500.00$$

$$p_{sh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , 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  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$shv = 0.008$   
 $ftv = 787.50$   
 $fyv = 656.25$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $fsv = fs = 656.25$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995$   
 and confined core properties:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = \text{confinement factor} = 1.04002$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < vs,c$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23279566$   
 $Mu = MRc (4.14) = 1.3221E+008$   
 $u = su (4.1) = 0.0002015$

-----  
 Calculation of ratio  $lb/ld$   
 -----

Adequate Lap Length:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu1$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 0.0002015$   
 $Mu = 1.3221E+008$   
 -----

with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00150304$   
 $N = 4666.932$   
 $fc = 30.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max( cu, cc) = 0.00595799$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00595799$   
 $we (5.4c) = 0.00377606$   
 $ase ((5.4d), TBDY) = 0.05494666$   
 $bo = 440.00$

ho = 190.00  
bi2 = 459400.00  
psh,min = Min(psh,x , psh,y) = 0.00314159

psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00  
From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/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, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = 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, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with  $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23279566$$

$$M_u = M_{Rc} (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

-----  
Calculation of ratio  $l_b/d$

-----  
Adequate Lap Length:  $l_b/d \geq 1$

-----  
Calculation of  $M_{u2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.0002015$$

$$M_u = 1.3221E+008$$

-----  
with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$fy_{we} = 656.25$$

$$f_{ce} = 30.00$$

From (5.A.5), TBDY, TBDY:  $cc = 0.00240019$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

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  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.17529176$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.17529176$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.23295708$$

$$2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.23295708$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.11294889$$

Case/Assumption: Unconfinedsd full section - Steel rupture

does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$s_u(4.9) = 0.23279566$

$\mu_u = M R_c(4.14) = 1.3221E+008$

$u = s_u(4.1) = 0.0002015$

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:

$u = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha(5A.5, TBDY) = 0.002$

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.00595799$

$w_e(5.4c) = 0.00377606$

$a_{se}((5.4d), TBDY) = 0.05494666$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00314159$

$\mu_{sh,x}(5.4d) = 0.00314159$

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 500.00$

$\mu_{sh,y}(5.4d) = 0.00628319$

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\mu_c = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$s_{u1} = 0.032$

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

$l_o/l_{o,min} = l_b/d = 1.00$

$s_{u1} = 0.4 * \mu_{u1,nominal}((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $\mu_{u1,nominal} = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs1 = fs = 656.25$

with  $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 787.50$

$fy2 = 656.25$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs2 = fs = 656.25$

with  $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$suv = 0.4 \cdot esuv\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fsv = fs = 656.25$

with  $Esv = Es = 200000.00$

1 =  $Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.17529176$

2 =  $Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.17529176$

v =  $Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08498995$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 31.20058

$cc$  (5A.5, TBDY) = 0.00240019

$c$  = confinement factor = 1.04002

1 =  $Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.23295708$

2 =  $Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.23295708$

v =  $Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11294889$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

$v < vs, c$  - RHS eq.(4.5) is satisfied

---

$su$  (4.9) = 0.23279566

$Mu = MRc$  (4.14) = 1.3221E+008

$u = su$  (4.1) = 0.0002015

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 302309.152$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Co10}$

$V_{Co10} = 302309.152$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $\lambda = 1$  (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $\lambda = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 500.00$   
-----

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 302309.152$

$V_{r2} = V_{Co2} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Co10}$

$V_{Co10} = 302309.152$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $\lambda = 1$  (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $\lambda = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 500.00$   
-----

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At local axis: 3  
-----

-----  
Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou}, \min > = 1$ )

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = 4.5261760E-048$

EDGE -B-

Shear Force,  $V_b = -4.5261760E-048$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 829.3805$

-Compression:  $A_{s,com} = 829.3805$

-Middle:  $A_{s,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.47299706$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3151E+008$

$M_{u1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3151E+008$

$M_{u2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00595799$$

$$w_e(5.4c) = 0.00377606$$

$$a_{se}((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00314159$$

$$\phi_{sh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$\phi_{sh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu_{1,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fs_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_{2,nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered

characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{s2} = f_s = 656.25$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$f_{yv} = 656.25$

$s_{uv} = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/d = 1.00$

$s_{uv} = 0.4 \cdot e_{suv,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{sv} = f_s = 656.25$

with  $E_{sv} = E_s = 200000.00$

1 =  $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

2 =  $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

v =  $Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

f<sub>cc</sub> (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

2 =  $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

v =  $Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$s_u$  (4.9) = 0.14815151

$\mu_u = MR_c$  (4.14) = 3.3151E+008

u =  $s_u$  (4.1) = 8.2199924E-005

-----  
Calculation of ratio  $l_b/d$

-----  
Adequate Lap Length:  $l_b/d \geq 1$

-----  
Calculation of  $\mu_{u1}$ -

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

u = 8.2199924E-005

$\mu_u = 3.3151E+008$

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

f<sub>c</sub> = 30.00

c<sub>o</sub> (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00595799$

$w_e$  (5.4c) = 0.00377606

$a_{se}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

$p_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

$p_{sh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00240019$

$c =$  confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu_1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_1_{nominal} = 0.08$ ,

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$fy_2 = 656.25$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 * esu_2_{nominal}$  ((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.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_2 = fs = 656.25$

with  $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_v = 0.4 * esuv_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v, ft_v, fy_v$ , 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, ASCE41-17.

with  $f_{sv} = f_s = 656.25$

with  $E_{sv} = E_s = 200000.00$

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

v =  $A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

v =  $A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v <  $v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio  $l_b/d$

-----  
Adequate Lap Length:  $l_b/d \geq 1$

-----  
Calculation of Mu2+

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.2199924E-005

Mu = 3.3151E+008

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

$f_c = 30.00$

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00595799$

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min =  $\text{Min}(psh,x, psh,y) = 0.00314159$

-----  
psh,x (5.4d) = 0.00314159

Ash =  $A_{stir} \cdot n_s = 78.53982$

No stirups,  $n_s = 2.00$

bk = 500.00

-----  
psh,y (5.4d) = 0.00628319

Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00  
d = 427.00  
d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $Asl,ten/(b*d)*(fs1/fc) = 0.22362502$

2 =  $Asl,com/(b*d)*(fs2/fc) = 0.22362502$

v =  $Asl,mid/(b*d)*(fsv/fc) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < vs,c - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----  
Calculation of Mu<sub>2</sub>-

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.2199924E-005

Mu = 3.3151E+008

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

fc = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = shear\_factor * Max(cu, cc) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00595799$

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

-----  
psh,x (5.4d) = 0.00314159

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

-----  
psh,y (5.4d) = 0.00628319

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

-----  
s = 100.00

fywe = 656.25

fce = 30.00

From ((5.A5), TBDY), TBDY:  $cc = 0.00240019$

c = confinement factor = 1.04002

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/d

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1,  $V_{r1} = 467242.766$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$  (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$M_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $\lambda = 1.00$

$s/d = 0.25$

$V_f$  ((11-3)-(11.4), ACI 440) =  $0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 250.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 467242.766$

$V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$  (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$M_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $\lambda = 1.00$

$s/d = 0.25$

$V_f$  ((11-3)-(11.4), ACI 440) =  $0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 250.00$

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\phi = 0.85$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $b/d > 1$ )

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 7.1383242E-010$

Shear Force,  $V_2 = -3012.903$

Shear Force,  $V_3 = -2.6198972E-013$

Axial Force,  $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-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,  $DbL = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = 1.0^*$   $\phi_u = 0.05034923$

$\phi_u = \phi_y + \phi_p = 0.05034923$

- Calculation of  $\phi_y$  -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00923029$  ((4.29), Biskinis Phd)

$M_y = 9.2818E+007$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 5.0279E+012$

factor = 0.30

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.726$

$E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 1.8256820\text{E-}005$   
with  $f_y = 525.00$   
 $d = 207.00$   
 $y = 0.30540153$   
 $A = 0.0199978$   
 $B = 0.01210998$   
with  $p_t = 0.00801334$   
 $p_c = 0.00801334$   
 $p_v = 0.00388525$   
 $N = 4665.726$   
 $b = 500.00$   
 $\mu = 0.20772947$   
 $y_{\text{comp}} = 3.3230728\text{E-}005$   
with  $f_c = 30.00$   
 $E_c = 25742.96$   
 $y = 0.3049475$   
 $A = 0.01980448$   
 $B = 0.01202411$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.04111895$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.29154496$

$d = 207.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$b_w = 500.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{yE} = f_{yI} = 0.00$

$\rho_l = \text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 2

Integration Section: (a)

## Calculation No. 11

column C1, Floor 1

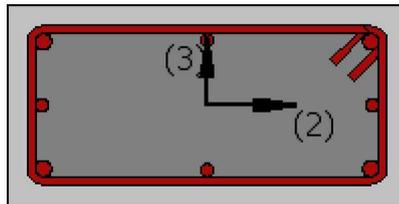
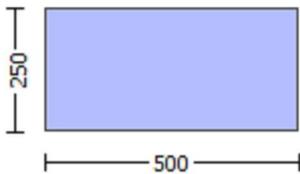
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material: Steel Strength,  $f_s = f_{sm} = 525.00$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, \min} = l_b/d \geq 1$ )

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 7.1383242E-010$

Shear Force,  $V_a = -2.6198972E-013$

EDGE -B-

Bending Moment,  $M_b = 7.2657463E-011$

Shear Force,  $V_b = 2.6198972E-013$

BOTH EDGES

Axial Force,  $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 829.3805$

-Compression:  $As_{c,com} = 829.3805$

-Middle:  $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 * V_n = 244283.30$

$V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI} = 244283.30$

$V_{CoI} = 244283.30$

$k_n = 1.00$

$displacement\_ductility\_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 20.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 7.1383242E-010$

$V_u = 2.6198972E-013$

$d = 0.8 * h = 200.00$

$N_u = 4665.726$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 131946.891$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.50$

$V_f$  ((11-3)-(11.4), ACI 440) =  $0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 297085.704$

$bw = 500.00$

$displacement\_ductility\_demand$  is calculated as /  $y$

- Calculation of /  $y$  for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation =  $3.7282056E-020$

$y = (M_y * L_s / 3) / E_{eff} = 0.00923029$  ((4.29), Biskinis Phd)

$M_y = 9.2818E+007$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) =  $1500.00$

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 5.0279E+012$

$factor = 0.30$

$A_g = 125000.00$

$f_c' = 30.00$

N = 4665.726  
Ec\*Ig = 1.6760E+013

Calculation of Yielding Moment My

Calculation of  $y$  and My according to Annex 7 -

y = Min(  $y_{ten}$ ,  $y_{com}$  )  
 $y_{ten} = 1.8256820E-005$   
with  $f_y = 525.00$   
d = 207.00  
y = 0.30540153  
A = 0.0199978  
B = 0.01210998  
with  $p_t = 0.00801334$   
pc = 0.00801334  
pv = 0.00388525  
N = 4665.726  
b = 500.00  
" = 0.20772947  
 $y_{comp} = 3.3230728E-005$   
with  $f_c = 30.00$   
Ec = 25742.96  
y = 0.3049475  
A = 0.01980448  
B = 0.01202411  
with Es = 200000.00

Calculation of ratio lb/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. 12

column C1, Floor 1

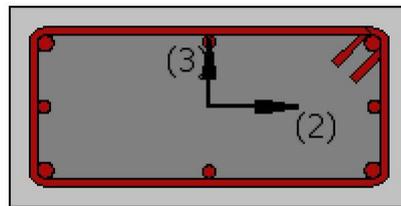
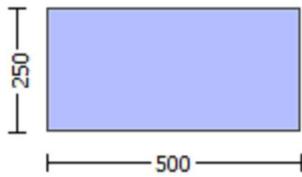
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcrs

Constant Properties

-----  
 Knowledge Factor,  $\gamma = 0.85$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$   
 Concrete Elasticity,  $E_c = 25742.96$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####  
 Section Height,  $H = 250.00$   
 Section Width,  $W = 500.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.04002  
 Element Length,  $L = 3000.00$   
 Primary Member  
 Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{ou, \min} >= 1$ )  
 No FRP Wrapping

-----  
 Stepwise Properties

-----  
 At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -7.3920505E-032$   
 EDGE -B-  
 Shear Force,  $V_b = 7.3920505E-032$   
 BOTH EDGES  
 Axial Force,  $F = -4666.932$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl,t} = 0.00$   
 -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 ,  $V_e/V_r = 0.29154496$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$   
with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.3221E+008$

$M_{u1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.3221E+008$

$M_{u2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$   
-----

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00595799$

$w_e$  (5.4c) = 0.00377606

$a_{se}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\rho_{sh,min} = \text{Min}(\rho_{sh,x} , \rho_{sh,y}) = 0.00314159$   
-----

$\rho_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 500.00$   
-----

$\rho_{sh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 250.00$   
-----

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\phi_c = 0.00240019$

$c$  = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$f_{t1} = 787.50$

$f_{y1} = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$$su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs1 = fs = 656.25$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 787.50$$

$$fy2 = 656.25$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$$lo/lou, min = lb/lb, min = 1.00$$

$$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs2 = fs = 656.25$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$$lo/lou, min = lb/ld = 1.00$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.17529176$$

$$2 = Asl, com / (b * d) * (fs2 / fc) = 0.17529176$$

$$v = Asl, mid / (b * d) * (fsv / fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl, ten / (b * d) * (fs1 / fc) = 0.23295708$$

$$2 = Asl, com / (b * d) * (fs2 / fc) = 0.23295708$$

$$v = Asl, mid / (b * d) * (fsv / fc) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

$v < vs, c$  - RHS eq.(4.5) is satisfied

---

$$su (4.9) = 0.23279566$$

$$Mu = MRc (4.14) = 1.3221E+008$$

$$u = su (4.1) = 0.0002015$$

Calculation of ratio  $lb/ld$

Adequate Lap Length:  $lb/ld \geq 1$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 0.0002015$$

$$\text{Mu} = 1.3221\text{E}+008$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e \text{ (5.4c)} = 0.00377606$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\text{psh,min} = \text{Min}(\text{psh,x}, \text{psh,y}) = 0.00314159$$

$$\text{psh,x (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$\text{psh,y (5.4d)} = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * esu_1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{su2\_nominal} = 0.08$ ,

For calculation of  $e_{su2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{s2} = f_s = 656.25$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv\_nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.23279566$$

$$\mu_u = M_{Rc} (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $\mu_{u2+}$

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.0002015$$

$$\mu_u = 1.3221E+008$$

-----  
with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

N = 4666.932  
fc = 30.00  
co (5A.5, TBDY) = 0.002  
Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00595799$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $cu = 0.00595799$   
we (5.4c) = 0.00377606  
ase ((5.4d), TBDY) = 0.05494666  
bo = 440.00  
ho = 190.00  
bi2 = 459400.00  
psh,min =  $\text{Min}(psh,x, psh,y) = 0.00314159$

-----  
psh,x (5.4d) = 0.00314159  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirups, ns = 2.00  
bk = 500.00

-----  
psh,y (5.4d) = 0.00628319  
Ash =  $\text{Astir} * ns = 78.53982$   
No stirups, ns = 2.00  
bk = 250.00

-----  
s = 100.00  
fywe = 656.25  
fce = 30.00  
From ((5.A5), TBDY), TBDY:  $cc = 0.00240019$   
c = confinement factor = 1.04002  
y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min =  $lb/ld = 1.00$   
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  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
with  $fs1 = fs = 656.25$   
with  $Es1 = Es = 200000.00$

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
lo/lou,min =  $lb/lb,min = 1.00$   
su2 =  $0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$   
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  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
with  $fs2 = fs = 656.25$   
with  $Es2 = Es = 200000.00$

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032  
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00  
lo/lou,min = lb/d = 1.00  
suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032  
From table 5A.1, TBDY: esuv\_nominal = 0.08,  
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.  
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.  
with fsv = fs = 656.25  
with Esv = Es = 200000.00  
1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.17529176  
2 = Asl,com/(b\*d)\*(fs2/fc) = 0.17529176  
v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00  
d = 177.00  
d' = 13.00  
fcc (5A.2, TBDY) = 31.20058  
cc (5A.5, TBDY) = 0.00240019  
c = confinement factor = 1.04002  
1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.23295708  
2 = Asl,com/(b\*d)\*(fs2/fc) = 0.23295708  
v = Asl,mid/(b\*d)\*(fsv/fc) = 0.11294889

Case/Assumption: Unconfined full section - Steel rupture  
' does not satisfy Eq. (4.3)

---->  
v < vs,c - RHS eq.(4.5) is satisfied  
---->  
su (4.9) = 0.23279566  
Mu = MRc (4.14) = 1.3221E+008  
u = su (4.1) = 0.0002015

-----  
Calculation of ratio lb/d

-----  
Adequate Lap Length: lb/d >= 1  
-----  
-----

Calculation of Mu2-  
-----  
-----

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 0.0002015  
Mu = 1.3221E+008  
-----

with full section properties:

b = 500.00  
d = 207.00  
d' = 43.00  
v = 0.00150304  
N = 4666.932  
fc = 30.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00595799  
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY: cu = 0.00595799  
we (5.4c) = 0.00377606  
ase ((5.4d), TBDY) = 0.05494666  
bo = 440.00  
ho = 190.00  
bi2 = 459400.00  
psh,min = Min(psh,x , psh,y) = 0.00314159

-----  
psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982

No stirrups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.17529176

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.17529176

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00

d = 177.00  
d' = 13.00  
fcc (5A.2, TBDY) = 31.20058  
cc (5A.5, TBDY) = 0.00240019  
c = confinement factor = 1.04002  
1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.23295708  
2 = Asl,com/(b\*d)\*(fs2/fc) = 0.23295708  
v = Asl,mid/(b\*d)\*(fsv/fc) = 0.11294889  
Case/Assumption: Unconfined full section - Steel rupture  
' does not satisfy Eq. (4.3)

--->  
v < vs,c - RHS eq.(4.5) is satisfied  
--->  
su (4.9) = 0.23279566  
Mu = MRc (4.14) = 1.3221E+008  
u = su (4.1) = 0.0002015

-----  
Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1  
-----  
-----  
-----

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 302309.152  
-----

Calculation of Shear Strength at edge 1, Vr1 = 302309.152  
Vr1 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 302309.152  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.1816411E-012  
Vu = 7.3920505E-032  
d = 0.8\*h = 200.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 164933.614  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00  
-----

Calculation of Shear Strength at edge 2, Vr2 = 302309.152  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 302309.152  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.1816411E-012  
Vu = 7.3920505E-032

d = 0.8\*h = 200.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 164933.614  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcrs

Constant Properties

-----  
Knowledge Factor, = 0.85  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 656.25  
#####  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.04002  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length (lo/lo<sub>u</sub>, min >= 1)  
No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = 4.5261760E-048  
EDGE -B-  
Shear Force, Vb = -4.5261760E-048  
BOTH EDGES  
Axial Force, F = -4666.932  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: As<sub>t</sub> = 0.00  
-Compression: As<sub>c</sub> = 2060.885  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: As<sub>t,ten</sub> = 829.3805

-Compression:  $A_{sl,com} = 829.3805$   
-Middle:  $A_{sl,mid} = 402.1239$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.47299706$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 3.3151E+008$

$M_{u1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 3.3151E+008$

$M_{u2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.2199924E-005$

$M_u = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_c = 0.00595799$

$\phi_{we}$  (5.4c) = 0.00377606

$\phi_{ase}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{sh,min} = \text{Min}(\phi_{sh,x} , \phi_{sh,y}) = 0.00314159$

$\phi_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 500.00$

$\phi_{sh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\phi_{cc} = 0.00240019$

$\phi_c$  = confinement factor = 1.04002

$\phi_{y1} = 0.0025$

$\phi_{sh1} = 0.008$

$f_{t1} = 787.50$

$f_{y1} = 656.25$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < vs,c - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_1$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.2199924E-005$

$\mu_1 = 3.3151E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu_c$ :  $\mu_c^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_c = 0.00595799$

$\mu_{we}$  (5.4c) = 0.00377606

$\mu_{ase}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00314159$

$\mu_{psh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

$\mu_{psh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\mu_{cc} = 0.00240019$

$c$  = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{su1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $\mu_{su1,nominal} = 0.08$ ,

For calculation of  $\mu_{su1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$$f_y2 = 656.25$$

$$s_u2 = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } f_{s2} = f_s = 656.25$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$f_{y_v} = 656.25$$

$$s_{u_v} = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{su_v,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{su_v,nominal} = 0.08$ ,

considering characteristic value  $f_{sy_v} = f_{sv}/1.2$ , 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  $f_{sy_v} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $M_{u2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

-----

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_c (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_c: \phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_c = 0.00595799$$

$$\phi_w (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\text{psh,min} = \text{Min}(\text{psh,x}, \text{psh,y}) = 0.00314159$$

$$\text{psh,x (5.4d)} = 0.00314159$$

$$\text{Ash} = \text{Astir} * \text{ns} = 78.53982$$

No stirups, ns = 2.00

$$b_k = 500.00$$

$$\text{psh,y (5.4d)} = 0.00628319$$

$$\text{Ash} = \text{Astir} * \text{ns} = 78.53982$$

No stirups, ns = 2.00

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,\text{min}} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,\text{min}} = l_b/l_{b,\text{min}} = 1.00$$

$$su_2 = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

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.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.15879823$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.15879823$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.22362502$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.22362502$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.14815151$$

$$Mu = MRc (4.14) = 3.3151E+008$$

$$u = su (4.1) = 8.2199924E-005$$

Calculation of ratio  $lb/ld$

Adequate Lap Length:  $lb/ld \geq 1$

Calculation of  $Mu2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$we (5.4c) = 0.00377606$$

$$ase ((5.4d), TBDY) = 0.05494666$$

$$bo = 440.00$$

$$ho = 190.00$$

bi2 = 459400.00  
psh,min = Min(psh,x , psh,y) = 0.00314159

psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/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  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (\text{lb}/\text{d})^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1,  $V_{r1} = 467242.766$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$$f'_c = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/d = 2.00$$

$$M_u = 3.6217549E-012$$

$$V_u = 4.5261760E-048$$

$$d = 0.8 * h = 400.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 329867.229$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

$V_s$  is multiplied by  $Col = 1.00$

$$s/d = 0.25$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 363854.192$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 467242.766$

$$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 467242.766$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
 $f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 3.6217549E-012$   
 $V_u = 4.5261760E-048$   
 $d = 0.8 \cdot h = 400.00$   
 $N_u = 4666.932$   
 $A_g = 125000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = 329867.229$   
 $A_v = 157079.633$   
 $f_y = 525.00$   
 $s = 100.00$   
 $V_s$  is multiplied by  $Col = 1.00$   
 $s/d = 0.25$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$   
 $b_w = 250.00$

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1  
At local axis: 3  
Integration Section: (a)  
Section Type: rcrs

#### Constant Properties

-----  
Knowledge Factor,  $\phi = 0.85$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$   
Concrete Elasticity,  $E_c = 25742.96$   
Steel Elasticity,  $E_s = 200000.00$   
Section Height,  $H = 250.00$   
Section Width,  $W = 500.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Primary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d > 1$ )  
No FRP Wrapping

#### Stepwise Properties

-----  
Bending Moment,  $M = -9.0404E+006$   
Shear Force,  $V_2 = -3012.903$   
Shear Force,  $V_3 = -2.6198972E-013$   
Axial Force,  $F = -4665.726$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 829.3805$   
-Compression:  $A_{sl,com} = 829.3805$   
-Middle:  $A_{sl,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $Db_L = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\mu_R = 1.0$   $\mu = 0.06032858$   
 $\mu = \gamma + \rho = 0.06032858$

- Calculation of  $\gamma$  -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.01029579$  ((4.29), Biskinis Phd))  
 $M_y = 2.0703E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3000.571  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 2.0112E+013$   
factor = 0.30  
 $A_g = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.726$   
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

$\gamma = \text{Min}(\gamma_{ten}, \gamma_{com})$   
 $\gamma_{ten} = 7.9424748E-006$   
with  $f_y = 525.00$   
 $d = 457.00$   
 $\gamma = 0.27680192$   
 $A = 0.01811617$   
 $B = 0.00994561$   
with  $p_t = 0.00725935$   
 $p_c = 0.00725935$   
 $p_v = 0.00351968$   
 $N = 4665.726$   
 $b = 250.00$   
 $\rho = 0.0940919$   
 $\gamma_{comp} = 1.6615364E-005$   
with  $f_c = 30.00$   
 $E_c = 25742.96$   
 $\gamma = 0.27625441$   
 $A = 0.01794104$   
 $B = 0.00986782$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b / l_d$

Adequate Lap Length:  $l_b / l_d \geq 1$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.05003279$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b / l_d < 1$   
shear control ratio  $V_y E / V_{col} O E = 0.47299706$

$d = 457.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$b_w = 250.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

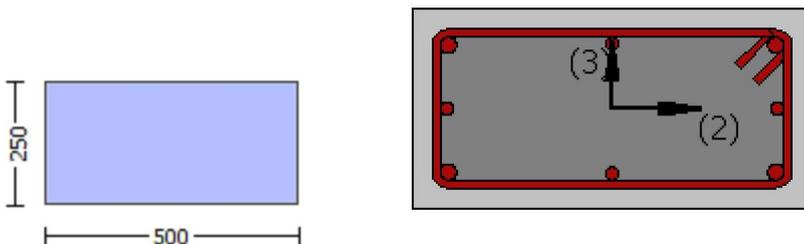
All these variables have already been given in Shear control ratio calculation.

NUD = 4665.726  
Ag = 125000.00  
fcE = 30.00  
fytE = fylE = 0.00  
pl = Area\_Tot\_Long\_Rein/(b\*d) = 0.01803838  
b = 250.00  
d = 457.00  
fcE = 30.00

-----  
End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1  
At local axis: 3  
Integration Section: (a)  
-----

### Calculation No. 13

column C1, Floor 1  
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity VRd  
Edge: End  
Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1  
At local axis: 2  
Integration Section: (b)  
Section Type: rcrs

Constant Properties

-----  
Knowledge Factor,  $\gamma = 0.85$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material: Steel Strength,  $f_s = f_{sm} = 525.00$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -9.0404E+006$

Shear Force,  $V_a = -3012.903$

EDGE -B-

Bending Moment,  $M_b = -0.00055925$

Shear Force,  $V_b = 3012.903$

BOTH EDGES

Axial Force,  $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 829.3805$

-Compression:  $As_{c,com} = 829.3805$

-Middle:  $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 18.66667$

-----  
New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 376230.192$

$V_n$  ((10.3), ASCE 41-17) =  $knI \cdot V_{CoIo} = 376230.192$

$V_{CoI} = 376230.192$

$knI = 1.00$

displacement\_ductility\_demand = 0.06549538

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

$f_c' = 20.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 0.00055925$

$V_u = 3012.903$

$d = 0.8 \cdot h = 400.00$

$N_u = 4665.726$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 263893.783$

$A_v = 157079.633$

$f_y = 420.00$

$s = 100.00$

$V_s$  is multiplied by  $CoI = 1.00$

$s/d = 0.25$

Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 297085.704  
bw = 250.00

displacement\_ductility\_demand is calculated as  $\phi_y$

- Calculation of  $\phi_y$  for END B -  
for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 6.7419844E-005  
 $y = (M_y * L_s / 3) / E_{eff} = 0.00102938$  ((4.29), Biskinis Phd)  
My = 2.0703E+008  
Ls = M/V (with Ls > 0.1\*L and Ls < 2\*L) = 300.00  
From table 10.5, ASCE 41\_17: Eleff = factor \* Ec \* Ig = 2.0112E+013  
factor = 0.30  
Ag = 125000.00  
fc' = 30.00  
N = 4665.726  
Ec \* Ig = 6.7039E+013

Calculation of Yielding Moment My

Calculation of  $\phi_y$  and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
y\_ten = 7.9424748E-006  
with fy = 525.00  
d = 457.00  
y = 0.27680192  
A = 0.01811617  
B = 0.00994561  
with pt = 0.00725935  
pc = 0.00725935  
pv = 0.00351968  
N = 4665.726  
b = 250.00  
" = 0.0940919  
y\_comp = 1.6615364E-005  
with fc = 30.00  
Ec = 25742.96  
y = 0.27625441  
A = 0.01794104  
B = 0.00986782  
with Es = 200000.00

Calculation of ratio 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. 14

column C1, Floor 1

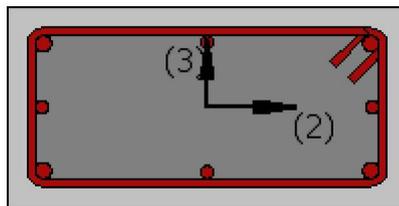
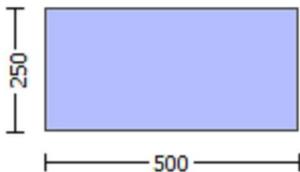
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, \min} \geq 1$ )

No FRP Wrapping

## Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -7.3920505E-032$

EDGE -B-

Shear Force,  $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 829.3805$

-Compression:  $As_{c,com} = 829.3805$

-Middle:  $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.29154496$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3221E+008$

$Mu_{1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3221E+008$

$Mu_{2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00595799$

$w_e$  (5.4c) = 0.00377606

$a_{se}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$bi_2 = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

$p_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirups,  $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/b,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.17529176

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.17529176

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00  
d = 177.00  
d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 31.20058  
 $c_c$  (5A.5, TBDY) = 0.00240019  
 $c$  = confinement factor = 1.04002  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $s_u$  (4.9) = 0.23279566  
 $M_u = M_{Rc}$  (4.14) = 1.3221E+008  
 $u = s_u$  (4.1) = 0.0002015

-----  
 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:

$u = 0.0002015$   
 $M_u = 1.3221E+008$

-----  
 with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00150304$   
 $N = 4666.932$   
 $f_c = 30.00$   
 $c_o$  (5A.5, TBDY) = 0.002  
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.00595799$   
 $w_e$  (5.4c) = 0.00377606  
 $a_{se}$  ((5.4d), TBDY) = 0.05494666  
 $b_o = 440.00$   
 $h_o = 190.00$   
 $b_{i2} = 459400.00$   
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

-----  
 $p_{sh,x}$  (5.4d) = 0.00314159  
 $A_{sh} = A_{stir} * n_s = 78.53982$   
 No stirups,  $n_s = 2.00$   
 $b_k = 500.00$

-----  
 $p_{sh,y}$  (5.4d) = 0.00628319  
 $A_{sh} = A_{stir} * n_s = 78.53982$   
 No stirups,  $n_s = 2.00$   
 $b_k = 250.00$

-----  
 $s = 100.00$   
 $f_{ywe} = 656.25$   
 $f_{ce} = 30.00$   
 From ((5.A5), TBDY), TBDY:  $c_c = 0.00240019$   
 $c$  = confinement factor = 1.04002  
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 787.50$   
 $fy_1 = 656.25$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.17529176

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.17529176

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08498995

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.23295708

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.23295708

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.11294889

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < vs,c - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.23279566

Mu = MRc (4.14) = 1.3221E+008

u = su (4.1) = 0.0002015

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.00595799$

$\mu_{we}$  (5.4c) = 0.00377606

$\mu_{ase}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00314159$

$\mu_{psh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

$\mu_{psh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $\mu_c = 0.00240019$

$c$  = confinement factor = 1.04002

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su_1 = 0.4 * \mu_{su1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $\mu_{su1,nominal} = 0.08$ ,

For calculation of  $\mu_{su1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $E_{s1} = E_s = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$$f_y2 = 656.25$$

$$s_u2 = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } f_{s2} = f_s = 656.25$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$f_{y_v} = 656.25$$

$$s_{u_v} = 0.032$$

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

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $y_v$ ,  $sh_v, ft_v, f_{y_v}$ , it is considered  
characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 656.25$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23279566$$

$$M_u = M_{Rc} (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $M_{u2}$ -

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.0002015$$

$$M_u = 1.3221E+008$$

-----

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$\phi_c (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_c: \phi_c^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_c = 0.00595799$$

$$\phi_w (5.4c) = 0.00377606$$

$$\phi_{se} ((5.4d), \text{TBDY}) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{sh, \min} = \text{Min}(\phi_{sh, x}, \phi_{sh, y}) = 0.00314159$$

---

$$\phi_{sh, x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 500.00$$

---

$$\phi_{sh, y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 250.00$$

---

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o, \min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } \text{esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o, \min} = l_b/l_{b, \min} = 1.00$$

$$su_2 = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } \text{esu2\_nominal} = 0.08,$$

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.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ftv = 787.50$$

$$fyv = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

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.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.17529176$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.17529176$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.23295708$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.23295708$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.23279566$$

$$Mu = MRc (4.14) = 1.3221E+008$$

$$u = su (4.1) = 0.0002015$$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 302309.152$   
-----

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 302309.152$

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VCol0$$

$$VCol0 = 302309.152$$

$$knl = 1 \text{ (zero step-static loading)}$$

-----  
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)

$$fc' = 30.00, \text{ but } fc'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

From (11.5.4.8), ACI 318-14:  $Vs = 164933.614$

$$Av = 157079.633$$

$$fy = 525.00$$

$$s = 100.00$$

Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 302309.152  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 302309.152  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*VF'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 6.1816411E-012  
Vu = 7.3920505E-032  
d = 0.8\*h = 200.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 164933.614  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.50  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 500.00

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcrs

#### Constant Properties

-----  
Knowledge Factor, = 0.85  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
New material: Steel Strength, fs = 1.25\*fsm = 656.25  
#####  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.04002  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou,min} >= 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 4.5261760E-048$   
EDGE -B-  
Shear Force,  $V_b = -4.5261760E-048$   
BOTH EDGES  
Axial Force,  $F = -4666.932$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 2060.885$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 829.3805$   
-Compression:  $As_{c,com} = 829.3805$   
-Middle:  $As_{c,mid} = 402.1239$   
-----  
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.47299706$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 3.3151E+008$   
 $Mu_{1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $Mu_{1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 3.3151E+008$   
 $Mu_{2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $Mu_{2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.2199924E-005$

$M_u = 3.3151E+008$   
-----

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00595799$

$w_e$  (5.4c) = 0.00377606

$\phi_{ase}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x} , \phi_{psh,y}) = 0.00314159$

psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

$$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.07699308$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl, ten} / (b * d) * (f_{s1} / f_c) = 0.22362502$$

$$2 = A_{sl, com} / (b * d) * (f_{s2} / f_c) = 0.22362502$$

$$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.10842425$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.14815151$$

$$M_u = M_{Rc} (4.14) = 3.3151E+008$$

$$u = s_u (4.1) = 8.2199924E-005$$

Calculation of ratio  $l_b / l_d$

Adequate Lap Length:  $l_b / l_d \geq 1$

Calculation of  $M_u1$ -

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$M_u = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

$$p_{sh, x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh, y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirrups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

c = confinement factor = 1.04002

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

$$su(4.9) = 0.14815151$$

$$Mu = MRc(4.14) = 3.3151E+008$$

$$u = su(4.1) = 8.2199924E-005$$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$

-----  
Calculation of  $Mu_{2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

-----  
with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$fc = 30.00$$

$$co(5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$we(5.4c) = 0.00377606$$

$$ase((5.4d), TBDY) = 0.05494666$$

$$bo = 440.00$$

$$ho = 190.00$$

$$bi2 = 459400.00$$

$$psh, \min = \text{Min}(psh, x, psh, y) = 0.00314159$$

-----  
 $psh, x(5.4d) = 0.00314159$

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 500.00$$

-----  
 $psh, y(5.4d) = 0.00628319$

$$Ash = Astir * ns = 78.53982$$

$$\text{No stirups, } ns = 2.00$$

$$bk = 250.00$$

-----  
 $s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 787.50$$

$$fy1 = 656.25$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/d = 1.00$$

$$su1 = 0.4 * esu1\_nominal((5.5), TBDY) = 0.032$$

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, ASCE41-17.

with  $f_{s1} = f_s = 656.25$   
 with  $E_{s1} = E_s = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 787.50$   
 $fy_2 = 656.25$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_{b,min} = 1.00$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{s2} = f_s = 656.25$   
 with  $E_{s2} = E_s = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 787.50$   
 $fy_v = 656.25$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $f_{sv} = f_s = 656.25$   
 with  $E_{sv} = E_s = 200000.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.15879823$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.15879823$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07699308$   
 and confined core properties:  
 $b = 190.00$   
 $d = 427.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = \text{confinement factor} = 1.04002$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.22362502$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.22362502$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.10842425$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14815151$   
 $Mu = MR_c (4.14) = 3.3151E+008$   
 $u = su (4.1) = 8.2199924E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Adequate Lap Length:  $l_b/l_d \geq 1$   
 -----  
 -----  
 -----

Calculation of  $Mu_2$ -  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we}(5.4c) = 0.00377606$$

$$\phi_{ase}((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$$

$$\phi_{psh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$\phi_{psh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * \phi_{su1\_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su1\_nominal} = 0.08,$$

For calculation of  $\phi_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } f_{s1} = f_s = 656.25$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * \phi_{su2\_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } \phi_{su2\_nominal} = 0.08,$$

For calculation of  $\phi_{su2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_2 = fs = 656.25$

with  $Es_2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou, \text{min} = lb/d = 1.00$

$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $esuv_{\text{nominal}} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{\text{nominal}}$  and  $yv, shv, ftv, fyv$ , it is considered

characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fsv = fs = 656.25$

with  $Es_v = Es = 200000.00$

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15879823$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.15879823$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.07699308$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

$fcc (5A.2, \text{TBDY}) = 31.20058$

$cc (5A.5, \text{TBDY}) = 0.00240019$

$c = \text{confinement factor} = 1.04002$

1 =  $Asl, \text{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.22362502$

2 =  $Asl, \text{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.22362502$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < vs, c$  - RHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14815151$

$Mu = MRc (4.14) = 3.3151E+008$

$u = su (4.1) = 8.2199924E-005$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr_1, Vr_2) = 467242.766$   
-----

Calculation of Shear Strength at edge 1,  $Vr_1 = 467242.766$

$Vr_1 = VCol ((10.3), \text{ASCE 41-17}) = knl \cdot VColO$

$VColO = 467242.766$

$knl = 1$  (zero step-static loading)  
-----

NOTE: In expression (10-3) ' $Vs = Av \cdot fy \cdot d / s$ ' is replaced by ' $Vs + f \cdot Vf$ '  
where  $Vf$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $= 1$  (normal-weight concrete)

$fc' = 30.00$ , but  $fc^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 3.6217549E-012$

$Vu = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$Nu = 4666.932$

Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 329867.229  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.25  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 250.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 467242.766  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 467242.766  
knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
fc' = 30.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 3.6217549E-012  
Vu = 4.5261760E-048  
d = 0.8\*h = 400.00  
Nu = 4666.932  
Ag = 125000.00  
From (11.5.4.8), ACI 318-14: Vs = 329867.229  
Av = 157079.633  
fy = 525.00  
s = 100.00  
Vs is multiplied by Col = 1.00  
s/d = 0.25  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 363854.192  
bw = 250.00

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1  
At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 2  
Integration Section: (b)  
Section Type: rcrs

Constant Properties

-----  
Knowledge Factor, = 0.85  
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
New material of Primary Member: Concrete Strength, fc = fcm = 30.00  
New material of Primary Member: Steel Strength, fs = fsm = 525.00  
Concrete Elasticity, Ec = 25742.96  
Steel Elasticity, Es = 200000.00  
Section Height, H = 250.00  
Section Width, W = 500.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Primary Member  
Smooth Bars  
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/d \geq 1$ )  
No FRP Wrapping

-----  
Stepwise Properties

-----  
Bending Moment,  $M = 7.2657463E-011$   
Shear Force,  $V2 = 3012.903$   
Shear Force,  $V3 = 2.6198972E-013$   
Axial Force,  $F = -4665.726$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-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,  $DbL = 18.66667$

-----  
New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.05034923$   
 $u = y + p = 0.05034923$

-----  
- Calculation of  $y$  -

-----  
 $y = (M_y * L_s / 3) / E_{eff} = 0.00923029$  ((4.29), Biskinis Phd))  
 $M_y = 9.2818E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 5.0279E+012$   
 $factor = 0.30$   
 $A_g = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.726$   
 $E_c * I_g = 1.6760E+013$

-----  
Calculation of Yielding Moment  $M_y$

-----  
Calculation of  $y$  and  $M_y$  according to Annex 7 -

-----  
 $y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 1.8256820E-005$   
with  $f_y = 525.00$   
 $d = 207.00$   
 $y = 0.30540153$   
 $A = 0.0199978$   
 $B = 0.01210998$   
with  $p_t = 0.00801334$   
 $p_c = 0.00801334$   
 $p_v = 0.00388525$   
 $N = 4665.726$   
 $b = 500.00$   
 $" = 0.20772947$   
 $y_{comp} = 3.3230728E-005$   
with  $f_c = 30.00$   
 $E_c = 25742.96$   
 $y = 0.3049475$   
 $A = 0.01980448$   
 $B = 0.01202411$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.04111895$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.29154496$

$d = 207.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$b_w = 500.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

$NUD = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{ytE} = f_{ylE} = 0.00$

$p_l = \text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01991193$

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 2

Integration Section: (b)

## Calculation No. 15

column C1, Floor 1

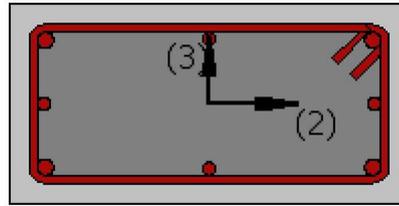
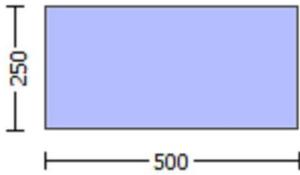
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 20.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 420.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material: Steel Strength,  $f_s = f_{sm} = 525.00$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 7.1383242E-010$

Shear Force,  $V_a = -2.6198972E-013$

EDGE -B-

Bending Moment,  $M_b = 7.2657463E-011$

Shear Force,  $V_b = 2.6198972E-013$

BOTH EDGES

Axial Force,  $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-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,  $D_{bL,ten} = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 244283.30$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{col0} = 244283.30$   
 $V_{col} = 244283.30$   
 $k_n = 1.00$   
 $displacement\_ductility\_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
 $f_c' = 20.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 7.2657463E-011$   
 $V_u = 2.6198972E-013$   
 $d = 0.8 \cdot h = 200.00$   
 $N_u = 4665.726$   
 $A_g = 125000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = 131946.891$   
 $A_v = 157079.633$   
 $f_y = 420.00$   
 $s = 100.00$   
 $V_s$  is multiplied by  $Col = 1.00$   
 $s/d = 0.50$   
 $V_f$  ((11-3)-(11.4), ACI 440) =  $0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 297085.704$   
 $b_w = 500.00$

$displacement\_ductility\_demand$  is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END B -  
for rotation axis 2 and integ. section (b)

From analysis, chord rotation  $\phi = 1.6647448E-020$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00923029$  ((4.29), Bisquis Phd)  
 $M_y = 9.2818E+007$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) =  $1500.00$   
From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$   
 $factor = 0.30$   
 $A_g = 125000.00$   
 $f_c' = 30.00$   
 $N = 4665.726$   
 $E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 1.8256820E-005$   
with  $f_y = 525.00$   
 $d = 207.00$   
 $y = 0.30540153$   
 $A = 0.0199978$   
 $B = 0.01210998$   
with  $pt = 0.00801334$   
 $pc = 0.00801334$   
 $pv = 0.00388525$   
 $N = 4665.726$

b = 500.00  
" = 0.20772947  
y\_comp = 3.3230728E-005  
with fc = 30.00  
Ec = 25742.96  
y = 0.3049475  
A = 0.01980448  
B = 0.01202411  
with Es = 200000.00

Calculation of ratio lb/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: (b)

## Calculation No. 16

column C1, Floor 1

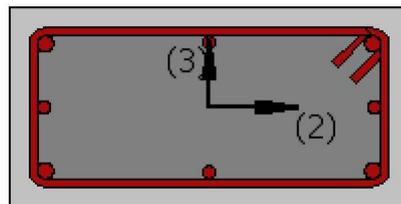
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( u)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 0.85

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, \min} > 1$ )

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 3

EDGE -A-

Shear Force,  $V_a = -7.3920505E-032$

EDGE -B-

Shear Force,  $V_b = 7.3920505E-032$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st, \text{ten}} = 829.3805$

-Compression:  $A_{st, \text{com}} = 829.3805$

-Middle:  $A_{st, \text{mid}} = 402.1239$

-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.29154496$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 88136.71$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3221E+008$

$M_{u1+} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3221E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3221E+008$

$M_{u2+} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3221E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 0.0002015$

$M_u = 1.3221E+008$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups,  $n_s = 2.00$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 1.00$$

$$su_1 = 0.4 * esu_1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * esu_2_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_2_{nominal} = 0.08,$$

For calculation of  $esu_2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , 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  $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$shv = 0.008$   
 $ftv = 787.50$   
 $fyv = 656.25$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.  
 with  $fsv = fs = 656.25$   
 with  $Esv = Es = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.17529176$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.17529176$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08498995$   
 and confined core properties:  
 $b = 440.00$   
 $d = 177.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 31.20058$   
 $cc (5A.5, TBDY) = 0.00240019$   
 $c = confinement\ factor = 1.04002$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.23295708$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.23295708$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.11294889$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' does not satisfy Eq. (4.3)  
 --->  
 $v < vs,c$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23279566$   
 $Mu = MRc (4.14) = 1.3221E+008$   
 $u = su (4.1) = 0.0002015$

-----  
 Calculation of ratio  $lb/ld$   
 -----

Adequate Lap Length:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu1$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 0.0002015$   
 $Mu = 1.3221E+008$   
 -----

with full section properties:

$b = 500.00$   
 $d = 207.00$   
 $d' = 43.00$   
 $v = 0.00150304$   
 $N = 4666.932$   
 $fc = 30.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max( cu, cc) = 0.00595799$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00595799$   
 $we (5.4c) = 0.00377606$   
 $ase ((5.4d), TBDY) = 0.05494666$   
 $bo = 440.00$

ho = 190.00  
bi2 = 459400.00  
psh,min = Min(psh,x , psh,y) = 0.00314159

psh,x (5.4d) = 0.00314159  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 500.00

psh,y (5.4d) = 0.00628319  
Ash = Astir\*ns = 78.53982  
No stirups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00  
From ((5.A5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002  
y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with  $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.17529176$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.17529176$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 31.20058$$

$$c_c (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.23295708$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.23295708$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11294889$$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23279566$$

$$M_u = M_{Rc} (4.14) = 1.3221E+008$$

$$u = s_u (4.1) = 0.0002015$$

-----  
Calculation of ratio  $l_b/d$

-----  
Adequate Lap Length:  $l_b/d \geq 1$

-----  
Calculation of  $M_{u2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 0.0002015$$

$$M_u = 1.3221E+008$$

-----  
with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e (5.4c) = 0.00377606$$

$$a_{se} ((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} (5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$p_{sh,y} (5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$fy_{we} = 656.25$$

$$f_{ce} = 30.00$$

From (5.A.5), TBDY, TBDY:  $cc = 0.00240019$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$$

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$$

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, ASCE41-17.

$$\text{with } fs_2 = fs = 656.25$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 787.50$$

$$fy_v = 656.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 656.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.17529176$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.17529176$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.08498995$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.23295708$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.23295708$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.11294889$$

Case/Assumption: Unconfinedsd full section - Steel rupture

does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$s_u(4.9) = 0.23279566$

$\mu_u = M R_c(4.14) = 1.3221E+008$

$u = s_u(4.1) = 0.0002015$

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:

$u = 0.0002015$

$\mu_u = 1.3221E+008$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

$\alpha(5A.5, TBDY) = 0.002$

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.00595799$

$w_e(5.4c) = 0.00377606$

$a_{se}((5.4d), TBDY) = 0.05494666$

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\text{psh}_{,min} = \text{Min}(\text{psh}_{,x}, \text{psh}_{,y}) = 0.00314159$

$\text{psh}_{,x}(5.4d) = 0.00314159$

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

$\text{psh}_{,y}(5.4d) = 0.00628319$

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

s = 100.00

fywe = 656.25

fce = 30.00

From ((5.A5), TBDY), TBDY:  $\mu_c = 0.00240019$

c = confinement factor = 1.04002

$y_1 = 0.0025$

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu_{1,nominal}((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs1 = fs = 656.25$

with  $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 787.50$

$fy2 = 656.25$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs2 = fs = 656.25$

with  $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 787.50$

$fyv = 656.25$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$suv = 0.4 \cdot esuv\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fsv = fs = 656.25$

with  $Esv = Es = 200000.00$

1 =  $Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.17529176$

2 =  $Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.17529176$

v =  $Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.08498995$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 31.20058

$cc$  (5A.5, TBDY) = 0.00240019

$c$  = confinement factor = 1.04002

1 =  $Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.23295708$

2 =  $Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.23295708$

v =  $Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11294889$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < vs, c$  - RHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.23279566

$Mu = MRc$  (4.14) = 1.3221E+008

$u = su$  (4.1) = 0.0002015

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 302309.152$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Co10}$

$V_{Co10} = 302309.152$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $= 1$  (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 500.00$   
-----

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 302309.152$

$V_{r2} = V_{Co2} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Co10}$

$V_{Co10} = 302309.152$

$k_{nl} = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $= 1$  (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.1816411E-012$

$\nu_u = 7.3920505E-032$

$d = 0.8 * h = 200.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 164933.614$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.50$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 500.00$   
-----

-----  
End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At local axis: 3  
-----

-----  
Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\phi = 0.85$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 656.25$

#####

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou}, \min >= 1$ )

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = 4.5261760E-048$

EDGE -B-

Shear Force,  $V_b = -4.5261760E-048$

BOTH EDGES

Axial Force,  $F = -4666.932$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 829.3805$

-Compression:  $A_{s,com} = 829.3805$

-Middle:  $A_{s,mid} = 402.1239$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.47299706$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 221004.455$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 3.3151E+008$

$M_{u1+} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 3.3151E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 3.3151E+008$

$M_{u2+} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 3.3151E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $M_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.2199924E-005$$

$$Mu = 3.3151E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00595799$$

$$\phi_{we}(5.4c) = 0.00377606$$

$$\phi_{ase}((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

$$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$$

$$\phi_{psh,x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 500.00$$

$$\phi_{psh,y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 787.50$$

$$fy_1 = 656.25$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$su_1 = 0.4 * \text{esu1\_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fs_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 656.25$$

$$\text{with } E_{s1} = E_s = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 787.50$$

$$fy_2 = 656.25$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$su_2 = 0.4 * \text{esu2\_nominal}((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and  $y_2, sh_2, ft_2, fy_2$ , it is considered

characteristic value  $f_{s2} = f_s/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{s2} = f_s = 656.25$

with  $E_{s2} = E_s = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$f_{yv} = 656.25$

$s_{uv} = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$s_{uv} = 0.4 \cdot e_{suv,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, f_{yv}$ , it is considered  
characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $f_{sv} = f_s = 656.25$

with  $E_{sv} = E_s = 200000.00$

1 =  $Asl_{,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

2 =  $Asl_{,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

v =  $Asl_{,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

f<sub>cc</sub> (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $Asl_{,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

2 =  $Asl_{,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

v =  $Asl_{,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$s_u$  (4.9) = 0.14815151

$\mu_u = MR_c$  (4.14) = 3.3151E+008

u =  $s_u$  (4.1) = 8.2199924E-005

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $\mu_{u1}$ -

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

u = 8.2199924E-005

$\mu_u = 3.3151E+008$

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

f<sub>c</sub> = 30.00

c<sub>o</sub> (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00595799$

$w_e$  (5.4c) = 0.00377606

$a_{se}$  ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$

$p_{sh,x}$  (5.4d) = 0.00314159

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 500.00$

$p_{sh,y}$  (5.4d) = 0.00628319

$A_{sh} = A_{stir} * n_s = 78.53982$

No stirrups,  $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$f_{ywe} = 656.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00240019$

$c = \text{confinement factor} = 1.04002$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 787.50$

$fy_1 = 656.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu_1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_1_{nominal} = 0.08$ ,

For calculation of  $esu_1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_1 = fs = 656.25$

with  $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 787.50$

$fy_2 = 656.25$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 * esu_2_{nominal}$  ((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.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.

with  $fs_2 = fs = 656.25$

with  $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 787.50$

$fy_v = 656.25$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_v = 0.4 * esuv_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $e_{sv\_nominal}$  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, ASCE41-17.

with  $f_{sv} = f_s = 656.25$

with  $E_{sv} = E_s = 200000.00$

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15879823$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.15879823$

v =  $A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07699308$

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.22362502$

2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.22362502$

v =  $A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v <  $v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/d

-----  
Adequate Lap Length: lb/d >= 1

-----  
Calculation of Mu2+

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.2199924E-005

Mu = 3.3151E+008

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

f<sub>c</sub> = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu:  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00595799$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00595799$

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min =  $\text{Min}(psh,x, psh,y) = 0.00314159$

-----  
psh,x (5.4d) = 0.00314159

Ash =  $A_{stir} \cdot n_s = 78.53982$

No stirrups,  $n_s = 2.00$

bk = 500.00

-----  
psh,y (5.4d) = 0.00628319

Ash = Astir\*ns = 78.53982  
No stirrups, ns = 2.00  
bk = 250.00

s = 100.00  
fywe = 656.25  
fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.00240019  
c = confinement factor = 1.04002

y1 = 0.0025  
sh1 = 0.008  
ft1 = 787.50  
fy1 = 656.25  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 787.50  
fy2 = 656.25  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 787.50  
fyv = 656.25  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00  
d = 427.00  
d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 =  $Asl_{ten}/(b*d)*(fs1/fc) = 0.22362502$

2 =  $Asl_{com}/(b*d)*(fs2/fc) = 0.22362502$

v =  $Asl_{mid}/(b*d)*(fsv/fc) = 0.10842425$

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

---

v < v<sub>s,c</sub> - RHS eq.(4.5) is satisfied

---

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----  
Calculation of Mu<sub>2</sub>-

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.2199924E-005

Mu = 3.3151E+008

-----  
with full section properties:

b = 250.00

d = 457.00

d' = 43.00

v = 0.00136161

N = 4666.932

fc = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00595799

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.00595799

we (5.4c) = 0.00377606

ase ((5.4d), TBDY) = 0.05494666

bo = 440.00

ho = 190.00

bi2 = 459400.00

psh,min = Min(psh,x , psh,y) = 0.00314159

-----  
psh,x (5.4d) = 0.00314159

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 500.00

-----  
psh,y (5.4d) = 0.00628319

Ash = Astir\*ns = 78.53982

No stirups, ns = 2.00

bk = 250.00

-----  
s = 100.00

fywe = 656.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.0025

sh1 = 0.008

ft1 = 787.50

fy1 = 656.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs1 = fs = 656.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 787.50

fy2 = 656.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 656.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 787.50

fyv = 656.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.

with fsv = fs = 656.25

with Esv = Es = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15879823

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.15879823

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07699308

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

cc (5A.5, TBDY) = 0.00240019

c = confinement factor = 1.04002

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.22362502

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.22362502

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.10842425

Case/Assumption: Unconfined full section - Steel rupture

' does not satisfy Eq. (4.3)

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.9) = 0.14815151

Mu = MRc (4.14) = 3.3151E+008

u = su (4.1) = 8.2199924E-005

-----  
Calculation of ratio lb/d

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

Calculation of Shear Strength at edge 1,  $V_{r1} = 467242.766$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$M_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.25$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 250.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 467242.766$

$V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l V_{Col0}$

$V_{Col0} = 467242.766$

$k_n l = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$M_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

$d = 0.8 * h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

From (11.5.4.8), ACI 318-14:  $V_s = 329867.229$

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

$V_s$  is multiplied by  $Col = 1.00$

$s/d = 0.25$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 363854.192$

$b_w = 250.00$

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor,  $\gamma = 0.85$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 525.00$

Concrete Elasticity,  $E_c = 25742.96$

Steel Elasticity,  $E_s = 200000.00$

Section Height,  $H = 250.00$

Section Width,  $W = 500.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $b/d > 1$ )

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = -0.00055925$

Shear Force,  $V_2 = 3012.903$

Shear Force,  $V_3 = 2.6198972E-013$

Axial Force,  $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-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,  $DbL = 18.66667$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = 1.0^*$   $\phi_u = 0.05106217$

$\phi_u = \phi_y + \phi_p = 0.05106217$

- Calculation of  $\phi_y$  -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00102938$  ((4.29), Biskinis Phd))

$M_y = 2.0703E+008$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 300.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 2.0112E+013$

factor = 0.30

$A_g = 125000.00$

$f_c' = 30.00$

$N = 4665.726$

$E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 7.9424748\text{E-}006$   
with  $f_y = 525.00$   
 $d = 457.00$   
 $\gamma = 0.27680192$   
 $A = 0.01811617$   
 $B = 0.00994561$   
with  $p_t = 0.00725935$   
 $p_c = 0.00725935$   
 $p_v = 0.00351968$   
 $N = 4665.726$   
 $b = 250.00$   
 $\gamma = 0.0940919$   
 $y_{\text{comp}} = 1.6615364\text{E-}005$   
with  $f_c = 30.00$   
 $E_c = 25742.96$   
 $\gamma = 0.27625441$   
 $A = 0.01794104$   
 $B = 0.00986782$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.05003279$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.47299706$

$d = 457.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$b_w = 250.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

$f_{yE} = f_{yI} = 0.00$

$\rho_l = \text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)