

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

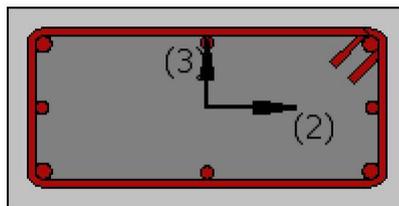
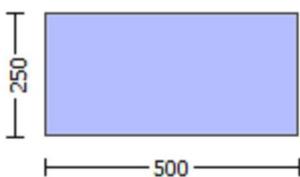
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

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

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

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

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Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

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 $V_R = 1.0 * V_n = 320061.987$

V_n ((10.3), ASCE 41-17) = $k_n l * V_{CoI} = 320061.987$

$V_{CoI} = 320061.987$

$k_n l = 1.00$

displacement_ductility_demand = 0.02641135

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)

$M / Vd = 4.00$

$M_u = 9.0404E+006$

$V_u = 3012.903$

$d = 0.8 * h = 400.00$

$N_u = 4665.726$

$A_g = 125000.00$

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 $CoI = 1.00$

$s / d = 0.25$

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

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

displacement ductility demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 0.00012382$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00468824$ ((4.29), Biskinis Phd))
 $M_y = 9.4271E+007$
 $L_s = M/V$ (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 ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.6045284E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806153$
 $A = 0.01821008$
 $B = 0.01003952$
with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4665.726$
 $b = 250.00$
 $" = 0.0940919$
 $y_{comp} = 1.6615364E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625441$
 $A = 0.01794104$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Lap Length: $I_d / I_d, \text{min} = 0.21819173$
 $I_b = 300.00$
 $I_d = 1374.938$
Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 I_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

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

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

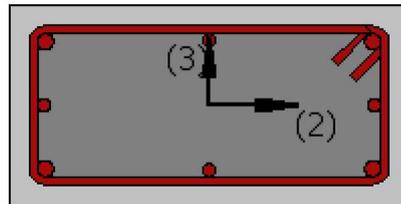
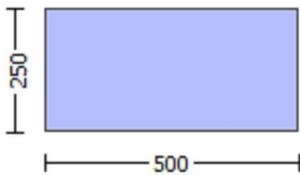
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_s = 1.25 \cdot f_{sm} = 656.25$

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Section Height, $H = 250.00$

Section Width, $W = 500.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.04002
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
Lap Length $l_o = 300.00$
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, $V_e/V_r = 0.10253309$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 4.6495E+007$
 $Mu_{1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 4.6495E+007$
 $Mu_{2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $Mu_{2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 2.0081816E-005$
 $M_u = 4.6495E+007$

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 ϕ_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: $c_u = 0.00595799$
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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/l_d = 0.17455338

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/l_d)^{2/3}), from 10.3.5, ASCE41-17.

with fs1 = fs = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/l_{b,min} = 0.17455338

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/l_d)^{2/3}), from 10.3.5, ASCE41-17.

with fs2 = fs = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/l_d = 0.17455338

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

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

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

For calculation of $\epsilon_{sv_nominal}$ and γ_v , ρ_{shv} , f_{tv} , f_{yv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , ρ_{sh1} , f_{t1} , 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 $f_{sv} = f_s = 256.2112$

with $E_{sv} = E_s = 200000.00$

1 = $A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06843691$

2 = $A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06843691$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03318153$

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 = $A_{s1,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09095043$

2 = $A_{s2,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09095043$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04409718$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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μ_u (4.9) = 0.24864441

$\mu_u = M/R_c$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_{u1} -

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

$u = 2.0081816E-005$

$\mu_u = 4.6495E+007$

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

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

$b_o = 440.00$

$h_o = 190.00$

$b_i^2 = 459400.00$

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

 $p_{sh,x}$ (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.A.5), TBDY), TBDY: $c_c = 0.00240019$

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

$y_1 = 0.00097604$

$sh_1 = 0.00312334$

$ft_1 = 307.4535$

$fy_1 = 256.2112$

$su_1 = 0.00312334$

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

$l_o/l_{o,min} = l_b/l_d = 0.17455338$

$su_1 = 0.4 * esu_{1,nominal}$ ((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 $fs_1 = fs = 256.2112$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00097604$

$sh_2 = 0.00312334$

$ft_2 = 307.4535$

$fy_2 = 256.2112$

$su_2 = 0.00312334$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.17455338$

$su_2 = 0.4 * esu_{2,nominal}$ ((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 $fs_2 = fs = 256.2112$

with $Es_2 = Es = 200000.00$

$y_v = 0.00097604$

$sh_v = 0.00312334$

$ft_v = 307.4535$

$fy_v = 256.2112$

$su_v = 0.00312334$

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

$l_o/l_{o,min} = l_b/l_d = 0.17455338$

$su_v = 0.4 * esu_{v,nominal}$ ((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 $\gamma_v, \gamma_{shv}, \gamma_{ftv}, \gamma_{fyv}$, it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $\gamma_1, \gamma_{sh1}, \gamma_{ft1}, \gamma_{fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $f_{sv} = f_s = 256.2112$
with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06843691$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06843691$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03318153$

and confined core properties:

$b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 31.20058$
 $cc \text{ (5A.5, TBDY)} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09095043$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09095043$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04409718$

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

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

--->
 $\mu_u \text{ (4.9)} = 0.24864441$
 $M_u = M_{Rc} \text{ (4.14)} = 4.6495E+007$
 $u = \mu_u \text{ (4.1)} = 2.0081816E-005$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.17455338$

$l_b = 300.00$
 $l_d = 1718.672$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$
 $db = 18.00$
Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

Calculation of μ_{u2+}

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

$u = 2.0081816E-005$
 $M_u = 4.6495E+007$

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 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = $lb/d = 0.17455338$

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 $fs1 = fs = 256.2112$

with $Es1 = Es = 200000.00$

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = $lb/lb,min = 0.17455338$

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 $fs2 = fs = 256.2112$

with $Es2 = Es = 200000.00$

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

$$l_0/l_{ou,min} = l_b/l_d = 0.17455338$$

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

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 γ_v , sh_v, ft_v, fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_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.

$$\text{with } f_{sv} = f_s = 256.2112$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.06843691$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.06843691$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.24864441$$

$$M_u = M_{Rc} (4.14) = 4.6495E+007$$

$$u = s_u (4.1) = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = $lb/d = 0.17455338$
 $su1 = 0.4 * \text{esu1_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $\text{esu1_nominal} = 0.08$,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value $\text{fsy1} = \text{fs1}/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $\text{fs1} = \text{fs} = 256.2112$
with $\text{Es1} = \text{Es} = 200000.00$

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = $lb/lb,\text{min} = 0.17455338$
 $su2 = 0.4 * \text{esu2_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $\text{esu2_nominal} = 0.08$,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value $\text{fsy2} = \text{fs2}/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $\text{fs2} = \text{fs} = 256.2112$
with $\text{Es2} = \text{Es} = 200000.00$

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.17455338$

$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$

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 $\gamma_v, \beta_{sv}, \beta_{fv}, \beta_{fv}$, it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

$\gamma_1, \beta_{sv}, \beta_{fv}, \beta_{fv}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 256.2112$

with $E_{sv} = E_s = 200000.00$

$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.06843691$

$2 = A_{s2,com}/(b*d) * (f_{s2}/f_c) = 0.06843691$

$v = A_{s,mid}/(b*d) * (f_{sv}/f_c) = 0.03318153$

and confined core properties:

$b = 440.00$

$d = 177.00$

$d' = 13.00$

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

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

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

$1 = A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.09095043$

$2 = A_{s2,com}/(b*d) * (f_{s2}/f_c) = 0.09095043$

$v = A_{s,mid}/(b*d) * (f_{sv}/f_c) = 0.04409718$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$\mu_u (4.9) = 0.24864441$

$M_u = M_{Rc} (4.14) = 4.6495E+007$

$u = \mu_u (4.1) = 2.0081816E-005$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$

where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$s = 100.00$

$n = 8.00$

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

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

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

$V_{CoI0} = 302309.152$

$k_{nl} = 1$ (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)
 $M/Vd = 2.00$
 $\mu_u = 6.1816411E-012$
 $V_u = 7.3920505E-032$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 164933.614$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 363854.192$
 $b_w = 500.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 302309.152$
 $V_{r2} = V_{\text{Col}}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{\text{Col}0}$
 $V_{\text{Col}0} = 302309.152$
 $k_{nl} = 1$ (zero step-static loading)

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

= 1 (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 6.1816411E-012$
 $V_u = 7.3920505E-032$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4666.932$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 164933.614$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$
 V_s is multiplied by $\text{Col} = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 363854.192$
 $b_w = 500.00$

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, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

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: $A_{st,com} = 829.3805$

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

Calculation of Shear Capacity ratio , $V_e/V_r = 0.15592384$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, 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

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.7831717E-006$

$Mu = 1.0928E+008$

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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = $lb/d = 0.17455338$
su1 = $0.4 * \text{esu1_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $\text{esu1_nominal} = 0.08$,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value $\text{fsy1} = \text{fs1}/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $\text{fs1} = \text{fs} = 256.2112$
with $\text{Es1} = \text{Es} = 200000.00$
y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = $lb/lb,\text{min} = 0.17455338$
su2 = $0.4 * \text{esu2_nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $\text{esu2_nominal} = 0.08$,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value $\text{fsy2} = \text{fs2}/1.2$, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
with $\text{fs2} = \text{fs} = 256.2112$
with $\text{Es2} = \text{Es} = 200000.00$
yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.17455338$

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

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 $\gamma_v, \delta_v, \beta_v, \gamma_{fv}$, it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

$\gamma_1, \delta_1, \beta_1, \gamma_{fv1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 256.2112$

with $E_{sv} = E_s = 200000.00$

1 = $A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.06199755$

2 = $A_{s2,com}/(b*d) * (f_{s2}/f_c) = 0.06199755$

v = $A_{s,mid}/(b*d) * (f_{sv}/f_c) = 0.03005942$

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

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

$\alpha_c (5A.5, TBDY) = 0.00240019$

c = confinement factor = 1.04002

1 = $A_{s1,ten}/(b*d) * (f_{s1}/f_c) = 0.08730704$

2 = $A_{s2,com}/(b*d) * (f_{s2}/f_c) = 0.08730704$

v = $A_{s,mid}/(b*d) * (f_{sv}/f_c) = 0.04233068$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$\mu_u (4.9) = 0.22187159$

$M_u = M_{Rc} (4.14) = 1.0928E+008$

$u = \mu_u (4.1) = 8.7831717E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

t = 1.00

s = 0.80

e = 1.00

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

s = 100.00

n = 8.00

Calculation of μ_{u1} -

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

$u = 8.7831717E-006$

$M_u = 1.0928E+008$

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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lou,min = lb/d = 0.17455338$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
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 $fs1 = fs = 256.2112$
with $Es1 = Es = 200000.00$
y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 0.17455338$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
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 $fs2 = fs = 256.2112$
with $Es2 = Es = 200000.00$
yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

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

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

γ_1 , sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.08730704$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08730704$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.22187159$$

$$Mu = MRc (4.14) = 1.0928E+008$$

$$u = su (4.1) = 8.7831717E-006$$

Calculation of ratio lb/ld

$$\text{Lap Length: } lb/ld = 0.17455338$$

$$lb = 300.00$$

$$ld = 1718.672$$

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$db = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu2+

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

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

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

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_i^2 = 459400.00$$

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

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

$$\text{Ash} = \text{Astir} * \text{ns} = 78.53982$$

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

$$b_k = 500.00$$

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

$$\text{Ash} = \text{Astir} * \text{ns} = 78.53982$$

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

$$b_k = 250.00$$

$$s = 100.00$$

$$f_{ywe} = 656.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00097604$$

$$sh_1 = 0.00312334$$

$$ft_1 = 307.4535$$

$$fy_1 = 256.2112$$

$$su_1 = 0.00312334$$

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

$$l_o/l_{o,\text{min}} = l_b/l_d = 0.17455338$$

$$su_1 = 0.4 * \text{esu1_nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of esu1_nominal and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = fs = 256.2112$$

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

$$y_2 = 0.00097604$$

$$sh_2 = 0.00312334$$

$$ft_2 = 307.4535$$

$$fy_2 = 256.2112$$

$$su_2 = 0.00312334$$

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

$$l_o/l_{o,\text{min}} = l_b/l_{b,\text{min}} = 0.17455338$$

$$su_2 = 0.4 * \text{esu2_nominal} ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of esu2_nominal and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_2 = fs = 256.2112$$

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

$$y_v = 0.00097604$$

$$sh_v = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lo_{min} = lb/ld = 0.17455338$$

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

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.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.06199755$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.06199755$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.03005942$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl_{ten}/(b*d)*(fs1/fc) = 0.08730704$$

$$2 = Asl_{com}/(b*d)*(fs2/fc) = 0.08730704$$

$$v = Asl_{mid}/(b*d)*(fsv/fc) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$$su (4.9) = 0.22187159$$

$$Mu = MRc (4.14) = 1.0928E+008$$

$$u = su (4.1) = 8.7831717E-006$$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.17455338$

$$lb = 300.00$$

$$ld = 1718.672$$

Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$db = 18.00$$

Mean strength value of all re-bars: $fy = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 7.85398$$

$$Atr = \text{Min}(Atr_x, Atr_y) = 157.0796$$

where Atr_x , Atr_y are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of $Mu2$ -

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

$$u = 8.7831717E-006$$

Mu = 1.0928E+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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$

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 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = $lb/d = 0.17455338$

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 $fs1 = fs = 256.2112$

with $Es1 = Es = 200000.00$

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = $lb/lb,min = 0.17455338$

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 $fs2 = fs = 256.2112$

with $Es2 = Es = 200000.00$

$yv = 0.00097604$
 $shv = 0.00312334$
 $ftv = 307.4535$
 $fyv = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou,min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = fs = 256.2112$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942$

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.08730704$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08730704$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04233068$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$su (4.9) = 0.22187159$

$Mu = MRc (4.14) = 1.0928E+008$

$u = su (4.1) = 8.7831717E-006$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.17455338$

$lb = 300.00$

$ld = 1718.672$

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 18.00$

Mean strength value of all re-bars: $fy = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 7.85398$

$Atr = Min(Atr_x,Atr_y) = 157.0796$

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis

$s = 100.00$

$n = 8.00$

Calculation of Shear Strength $Vr = Min(Vr1,Vr2) = 467242.766$

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

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

VCol0 = 467242.766

kn1 = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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, Vr2 = 467242.766

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 467242.766

kn1 = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6217549E-012$

$\nu_u = 4.5261760E-048$

$d = 0.8 \cdot h = 400.00$

$N_u = 4666.932$

$A_g = 125000.00$

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

$A_v = 157079.633$

$f_y = 525.00$

$s = 100.00$

V_s is multiplied by $Col = 1.00$

$s/d = 0.25$

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: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 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
 Lap Length $l_b = 300.00$
 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: $A_{sl,t} = 0.00$
 -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 $u_{,R} = 1.0^*$ $u = 0.00420469$
 $u = y + p = 0.00420469$

 - Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00420469$ ((4.29), Biskinis Phd))
 $M_y = 4.2282E+007$
 $L_s = M/V$ (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 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 8.2854890E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 237.8454$
 $d = 207.00$
 $y = 0.30661195$
 $A = 0.02010146$
 $B = 0.01221365$

with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.726$
 $b = 500.00$
 $" = 0.20772947$
 $y_{comp} = 3.3230728E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.3049475$
 $A = 0.01980448$
 $B = 0.01202411$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Lap Length: $l_{d,min} = 0.21819173$

$l_b = 300.00$

$l_d = 1374.938$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 525.00$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.10253309$

$d = 207.00$

$s = 0.00$

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

$A_v = 157.0796$, 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.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f_{cE} = 30.00$

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

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

$b = 500.00$

$d = 207.00$

$f_{cE} = 30.00$

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

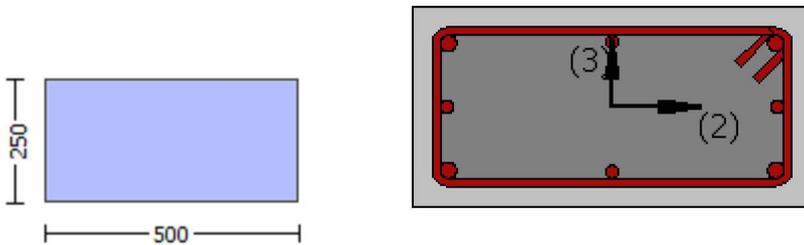
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

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

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = l_b = 300.00$
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: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 829.3805$
-Compression: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

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 $CoI = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 500.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 3.7282056E-020$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00420469$ ((4.29), Biskinis Phd))
 $M_y = 4.2282E+007$
 $L_s = M/V$ (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 -

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

$y_{ten} = 8.2854890E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 237.8454$

$d = 207.00$

$y = 0.30661195$

$A = 0.02010146$

$B = 0.01221365$

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 I_b / I_d

Lap Length: $I_d / I_{d,min} = 0.21819173$

$I_b = 300.00$

$I_d = 1374.938$

Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 525.00$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

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

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

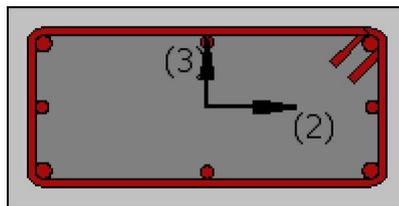
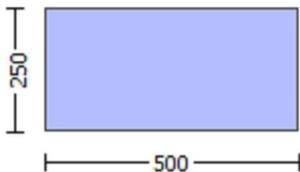
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Lap Length $l_o = 300.00$

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, $V_e/V_r = 0.10253309$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 4.6495E+007$

$Mu_{1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 4.6495E+007$

$Mu_{2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α_1 (5A.5, TBDY) = 0.002

Final value of ϕ_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: $\phi_u = 0.00595799$

ϕ_w (5.4c) = 0.00377606

ϕ_{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

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

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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 su (4.9) = 0.24864441
 $Mu = MRc$ (4.14) = 4.6495E+007
 $u = su$ (4.1) = 2.0081816E-005

 Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 = 1
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$
 where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

 Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 2.0081816E-005$
 $Mu = 4.6495E+007$

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 : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00595799$
 w_e (5.4c) = 0.00377606
 ase ((5.4d), TBDY) = 0.05494666
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh, min = \text{Min}(psh,x, psh,y) = 0.00314159$

 psh,x (5.4d) = 0.00314159
 $A_{sh} = A_{stir} * n_s = 78.53982$

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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

$d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.24864441$
 $Mu = MRc (4.14) = 4.6495E+007$
 $u = su (4.1) = 2.0081816E-005$

 Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $fc' = 30.00$, but $fc^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 2.0081816E-005$
 $Mu = 4.6495E+007$

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.24864441$$

$$M_u = MR_c (4.14) = 4.6495E+007$$

$$u = s_u (4.1) = 2.0081816E-005$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2 -

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

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)

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

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

$$\text{Ash} = \text{Astir} * ns = 78.53982$$

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

$$bk = 500.00$$

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

$$\text{Ash} = \text{Astir} * ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

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

$$lo/lou,min = lb/d = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), \text{ TBDY}) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

$$\text{with } fs1 = fs = 256.2112$$

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

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

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

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), \text{ TBDY}) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

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

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/d = 0.17455338$$

$$suv = 0.4 * esuv_nominal ((5.5), \text{ TBDY}) = 0.032$$

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.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = \text{Asl,ten}/(b*d) * (fs1/fc) = 0.06843691$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.06843691$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.24864441$$

$$M_u = M_{Rc} (4.14) = 4.6495E+007$$

$$u = s_u (4.1) = 2.0081816E-005$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

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

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

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

$$V_{Co10} = 302309.152$$

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

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).

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

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

$$M/Vd = 2.00$$

$$M_u = 6.1816411E-012$$

$$V_u = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$N_u = 4666.932$$

$$A_g = 125000.00$$

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

$$A_v = 157079.633$$

$$f_y = 525.00$$

s = 100.00
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, = 1.00
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
Lap Length $l_o = 300.00$
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: $As_{,ten} = 829.3805$
-Compression: $As_{,com} = 829.3805$
-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.15592384$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$
with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.0928E+008$
 $Mu_{1+} = 1.0928E+008$, 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
 $Mu_{1-} = 1.0928E+008$, 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
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.0928E+008$
 $Mu_{2+} = 1.0928E+008$, 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
 $Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.7831717E-006$
 $Mu = 1.0928E+008$

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 ϕ_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: $\phi_u = 0.00595799$
 $\phi_{we} (5.4c) = 0.00377606$
 $\phi_{ase} ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$

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

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

$$\text{Ash} = \text{Astir} * ns = 78.53982$$

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

$$bk = 500.00$$

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

$$\text{Ash} = \text{Astir} * ns = 78.53982$$

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

$$bk = 250.00$$

$$s = 100.00$$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

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

$$lo/lou,min = lb/d = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TB DY.

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

$$\text{with } fs1 = fs = 256.2112$$

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

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

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

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), \text{TB DY}) = 0.032$$

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TB DY.

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

$$\text{with } fs2 = fs = 256.2112$$

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

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/d = 0.17455338$$

$$suv = 0.4 * esuv_nominal ((5.5), \text{TB DY}) = 0.032$$

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

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

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

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = \text{Asl,ten}/(b*d) * (fs1/fc) = 0.06199755$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.06199755$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03005942$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22187159$$

$$M_u = M_{Rc} (4.14) = 1.0928E+008$$

$$u = s_u (4.1) = 8.7831717E-006$$

 Calculation of ratio l_b/d

 Lap Length: $l_b/d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

 Calculation of M_u1 -

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

$$u = 8.7831717E-006$$

$$M_u = 1.0928E+008$$

 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)

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

$$w_e (5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with $E_{sv} = E_s = 200000.00$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.06199755$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.06199755$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03005942$$

and confined core properties:

$$b = 190.00$$

$$d = 427.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22187159$$

$$\mu_u = M_{Rc} (4.14) = 1.0928E+008$$

$$u = s_u (4.1) = 8.7831717E-006$$

Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.17455338$

$$l_b = 300.00$$

$$d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of μ_{u2+}

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

$$u = 8.7831717E-006$$

$$\mu_u = 1.0928E+008$$

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)

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

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

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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/lb = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y2, sh2,ft2,fy2, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.

with fs2 = fs = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/lb = 0.17455338

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

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

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

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

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

with $f_{sv} = f_s = 256.2112$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06199755$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06199755$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03005942$

and confined core properties:

$b = 190.00$

$d = 427.00$

$d' = 13.00$

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

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

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.08730704$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08730704$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04233068$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.22187159$

$Mu = MRc (4.14) = 1.0928E+008$

$u = su (4.1) = 8.7831717E-006$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.17455338$

$lb = 300.00$

$ld = 1718.672$

Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$db = 18.00$

Mean strength value of all re-bars: $fy = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of Mu_2 -

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

$u = 8.7831717E-006$

$Mu = 1.0928E+008$

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

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 = 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/l_d = 0.17455338

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/l_d)^{2/3}), from 10.3.5, ASCE41-17.

with fs1 = fs = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/l_{b,min} = 0.17455338

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/l_d)^{2/3}), from 10.3.5, ASCE41-17.

with fs2 = fs = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/l_d = 0.17455338

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

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

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

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

with $f_{sv} = f_s = 256.2112$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.06199755$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.06199755$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.03005942$

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 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.08730704$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08730704$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04233068$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

μ (4.9) = 0.22187159

$\mu_u = MR_c$ (4.14) = 1.0928E+008

$u = \mu$ (4.1) = 8.7831717E-006

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

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) = $k_{nl} \cdot V_{Col0}$

$V_{Col0} = 467242.766$

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

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

= 1 (normal-weight concrete)

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

$M/V_d = 2.00$

$\mu_u = 3.6217549E-012$

$V_u = 4.5261760E-048$

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

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: 3
Integration Section: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length $l_b = 300.00$
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: $A_{st} = 0.00$
-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 $u_{,R} = 1.0^*$ $u = 0.00468824$
 $u = y + p = 0.00468824$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00468824$ ((4.29), Biskinis Phd)
 $M_y = 9.4271E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.571
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.726$
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.6045284E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806153$
 $A = 0.01821008$
 $B = 0.01003952$
with $pt = 0.00725935$
 $pc = 0.00725935$
 $pv = 0.00351968$
 $N = 4665.726$
 $b = 250.00$
 $" = 0.0940919$
 $y_{comp} = 1.6615364E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625441$
 $A = 0.01794104$
 $B = 0.00986782$

with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.21819173$

$l_b = 300.00$

$l_d = 1374.938$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 525.00$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

- Calculation of ρ -

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

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$
shear control ratio $V_y E / V_{col} I_{OE} = 0.15592384$

$d = 457.00$

$s = 0.00$

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

$A_v = 157.0796$, 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.

$N_{UD} = 4665.726$

$A_g = 125000.00$

$f'_c E = 30.00$

$f_{yt} E = f_{yl} E = 0.00$

$\rho_l = \text{Area}_{\text{Tot_Long_Rein}} / (b * d) = 0.01803838$

$b = 250.00$

$d = 457.00$

$f'_c E = 30.00$

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

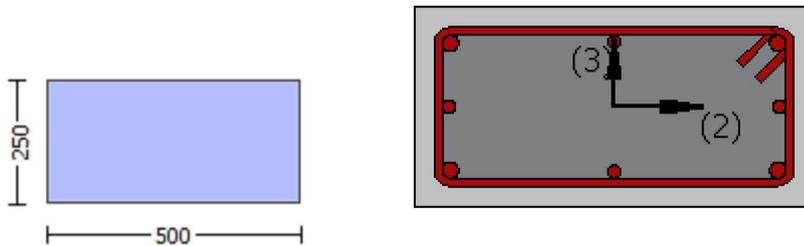
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

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

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

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: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 829.3805$
 -Compression: $A_{sl,com} = 829.3805$
 -Middle: $A_{sl,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

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) = $k_n \cdot V_{CoI0} = 376230.192$
 $V_{CoI} = 376230.192$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.14383353$

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 $Col = 1.00$
 $s/d = 0.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 6.7419844E-005$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00046874$ ((4.29), Biskinis Phd)
 $M_y = 9.4271E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.0112E+013$
 $factor = 0.30$
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.726$
 $E_c \cdot I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 3.6045284\text{E-}006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806153$
 $A = 0.01821008$
 $B = 0.01003952$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.726$
 $b = 250.00$
 $" = 0.0940919$
 $y_{\text{comp}} = 1.6615364\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625441$
 $A = 0.01794104$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Lap Length: $l_d/l_{d,\text{min}} = 0.21819173$
 $l_b = 300.00$
 $l_d = 1374.938$
Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,\text{min}}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

At local axis: 2

Integration Section: (b)

Calculation No. 6

column C1, Floor 1

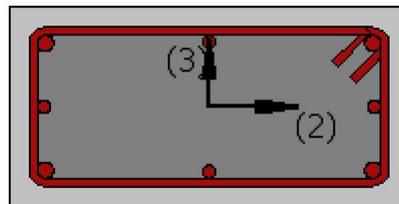
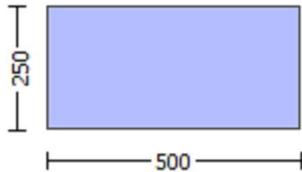
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Lap Length $l_o = 300.00$

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: $As_{l,com} = 829.3805$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.10253309$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$

with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 4.6495E+007$
 $Mu_{1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 4.6495E+007$

$Mu_{2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_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, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 256.2112$$

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

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

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

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

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

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

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

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.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.06843691$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.06843691$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09095043$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09095043$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.04409718$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.24864441

$\mu_u = M/R_c$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_u

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

$u = 2.0081816E-005$

$\mu_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

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

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

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

we (5.4c) = 0.00377606

ase ((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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.00097604$
 $sh_1 = 0.00312334$
 $ft_1 = 307.4535$
 $fy_1 = 256.2112$
 $su_1 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 256.2112$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00097604$
 $sh_2 = 0.00312334$
 $ft_2 = 307.4535$
 $fy_2 = 256.2112$
 $su_2 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.17455338$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 256.2112$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00097604$
 $sh_v = 0.00312334$
 $ft_v = 307.4535$
 $fy_v = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 256.2112$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1 / fc) = 0.06843691$
 $2 = Asl, \text{com}/(b * d) * (fs_2 / fc) = 0.06843691$
 $v = Asl, \text{mid}/(b * d) * (fsv / fc) = 0.03318153$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 31.20058$
 $cc \text{ (5A.5, TBDY)} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten}/(b * d) * (fs_1 / fc) = 0.09095043$
 $2 = Asl, \text{com}/(b * d) * (fs_2 / fc) = 0.09095043$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04409718$$

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

--->

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

--->

$$s_u(4.9) = 0.24864441$$

$$M_u = M_{Rc}(4.14) = 4.6495E+007$$

$$u = s_u(4.1) = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr, x}, A_{tr, y}) = 157.0796$$

where $A_{tr, x}$, $A_{tr, y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2+

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

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

No stirrups, 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

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

$$\text{su (4.9)} = 0.24864441$$

$$\text{Mu} = \text{MRc (4.14)} = 4.6495\text{E}+007$$

$$u = \text{su (4.1)} = 2.0081816\text{E}-005$$

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.17455338

$$lb = 300.00$$

$$ld = 1718.672$$

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$db = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu2-

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

$$u = 2.0081816\text{E}-005$$

$$\text{Mu} = 4.6495\text{E}+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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: $c_u = 0.00595799$

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

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

$$su \text{ (4.9)} = 0.24864441$$

$$\mu_u = MR_c \text{ (4.14)} = 4.6495E+007$$

$$u = su \text{ (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

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

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

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

$$V_{Col0} = 302309.152$$

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

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 is multiplied by $Col = 1.00$

$$s/d = 0.50$$

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

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

$$b_w = 500.00$$

Calculation of Shear Strength at edge 2, Vr2 = 302309.152

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 302309.152

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

M/Vd = 2.00

Mu = 6.1816411E-012

Vu = 7.3920505E-032

d = 0.8*h = 200.00

Nu = 4666.932

Ag = 125000.00

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

Av = 157079.633

fy = 525.00

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.50

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

From (11-11), ACI 440: Vs + Vf <= 363854.192

bw = 500.00

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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

Lap Length lo = 300.00

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15592384$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, 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

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.7831717E-006$

$M_u = 1.0928E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

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

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 stirrups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

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

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

$$su \text{ (4.9)} = 0.22187159$$

$$Mu = MRc \text{ (4.14)} = 1.0928E+008$$

$$u = su \text{ (4.1)} = 8.7831717E-006$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_1 -

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

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

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.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

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) = 0.08730704
2 = Asl,com/(b*d)*(fs2/fc) = 0.08730704
v = Asl,mid/(b*d)*(fsv/fc) = 0.04233068
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

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

--->
su (4.9) = 0.22187159
Mu = MRc (4.14) = 1.0928E+008
u = su (4.1) = 8.7831717E-006

Calculation of ratio lb/l_d

Lap Length: lb/l_d = 0.17455338

lb = 300.00

ld = 1718.672

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

db = 18.00

Mean strength value of all re-bars: fy = 656.25

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

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 7.85398

Atr = Min(Atr_x, Atr_y) = 157.0796

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y local axis

s = 100.00

n = 8.00

Calculation of Mu₂₊

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

u = 8.7831717E-006

Mu = 1.0928E+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: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$

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 = 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338
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 = 256.2112
with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755
2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755
v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$db = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$s = 100.00$

$n = 8.00$

 Calculation of Mu_2 -

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

$u = 8.7831717E-006$

$Mu = 1.0928E+008$

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

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

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

$we (5.4c) = 0.00377606$

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

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

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

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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.03005942$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl, ten} / (b * d) * (f_{s1} / f_c) = 0.08730704$
 $2 = A_{sl, com} / (b * d) * (f_{s2} / f_c) = 0.08730704$
 $v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s, y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b / l_d

Lap Length: $l_b / l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 467242.766$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M / Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 * h = 400.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$

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, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 7.2657463E-011$

Shear Force, $V2 = 3012.903$

Shear Force, $V3 = 2.6198972E-013$

Axial Force, $F = -4665.726$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2060.885$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle: $As_{mid} = 402.1239$

Mean Diameter of Tension Reinforcement, $Db_L = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.00420469$

$u = y + p = 0.00420469$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.00420469$ ((4.29), Biskinis Phd))

$My = 4.2282E+007$

$L_s = M/V$ (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

$Ag = 125000.00$

$fc' = 30.00$

$N = 4665.726$

$E_c * I_g = 1.6760E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{ten} = 8.2854890E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 237.8454$

$d = 207.00$

$y = 0.30661195$

$A = 0.02010146$

$B = 0.01221365$

with $pt = 0.00801334$

$pc = 0.00801334$

$pv = 0.00388525$

$N = 4665.726$

$b = 500.00$

" = 0.20772947

$y_{comp} = 3.3230728E-005$

with $fc = 30.00$

$E_c = 25742.96$

$y = 0.3049475$

$A = 0.01980448$

$B = 0.01202411$

with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_{d,min} = 0.21819173$

$$l_b = 300.00$$

$$l_d = 1374.938$$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 525.00$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.10253309$

$$d = 207.00$$

$$s = 0.00$$

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

$A_v = 157.0796$, 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.

$$N_{UD} = 4665.726$$

$$A_g = 125000.00$$

$$f'_c E = 30.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

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

$$b = 500.00$$

$$d = 207.00$$

$$f'_c E = 30.00$$

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

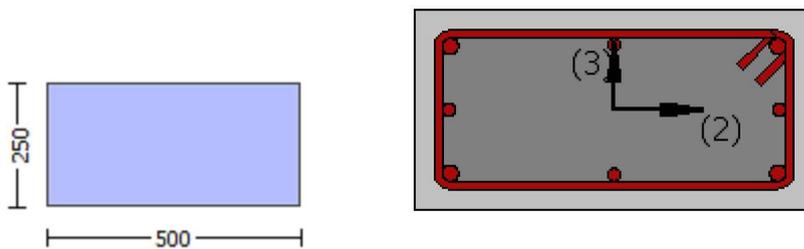
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

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

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

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: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2060.885$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 829.3805$
 -Compression: $A_{sl,com} = 829.3805$
 -Middle: $A_{sl,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

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) = $k_n \cdot V_{CoI} = 244283.30$
 $V_{CoI} = 244283.30$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00$

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

$\phi = 1$ (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 $CoI = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 500.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 1.6647448E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00420469$ ((4.29), Biskinis Phd)
 $M_y = 4.2282E+007$
 $L_s = M/V$ (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 y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 8.2854890\text{E}-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 237.8454$
 $d = 207.00$
 $y = 0.30661195$
 $A = 0.02010146$
 $B = 0.01221365$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.726$
 $b = 500.00$
 $" = 0.20772947$
 $y_{\text{comp}} = 3.3230728\text{E}-005$
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

Lap Length: $l_d/l_d, \text{min} = 0.21819173$
 $l_b = 300.00$
 $l_d = 1374.938$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

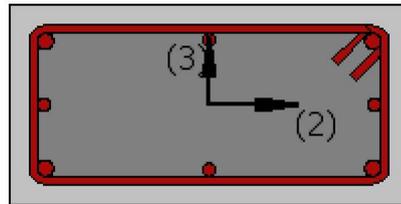
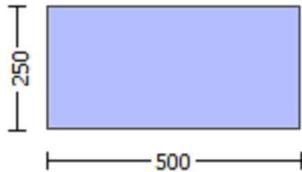
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

Lap Length $l_o = 300.00$

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, $V_e/V_r = 0.10253309$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 4.6495E+007$

$Mu_{1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 4.6495E+007$

$Mu_{2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_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, $n_s = 2.00$

$b_k = 500.00$

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

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

No stirups, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 256.2112$$

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

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

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

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

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

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

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

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.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09095043$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09095043$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04409718$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.24864441

$\mu_u = M/R_c$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_{u1} -

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

$u = 2.0081816E-005$

$\mu_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

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

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

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

we (5.4c) = 0.00377606

ase ((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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.00097604$
 $sh_1 = 0.00312334$
 $ft_1 = 307.4535$
 $fy_1 = 256.2112$
 $su_1 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 256.2112$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00097604$
 $sh_2 = 0.00312334$
 $ft_2 = 307.4535$
 $fy_2 = 256.2112$
 $su_2 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.17455338$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 256.2112$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00097604$
 $sh_v = 0.00312334$
 $ft_v = 307.4535$
 $fy_v = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 256.2112$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1 / fc) = 0.06843691$
 $2 = Asl, \text{com}/(b * d) * (fs_2 / fc) = 0.06843691$
 $v = Asl, \text{mid}/(b * d) * (fsv / fc) = 0.03318153$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 31.20058$
 $cc \text{ (5A.5, TBDY)} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten}/(b * d) * (fs_1 / fc) = 0.09095043$
 $2 = Asl, \text{com}/(b * d) * (fs_2 / fc) = 0.09095043$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04409718$$

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

--->

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

--->

$$s_u(4.9) = 0.24864441$$

$$M_u = M_{Rc}(4.14) = 4.6495E+007$$

$$u = s_u(4.1) = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2+

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

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

No stirrups, 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

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

$$\text{su (4.9)} = 0.24864441$$

$$\text{Mu} = \text{MRc (4.14)} = 4.6495\text{E}+007$$

$$u = \text{su (4.1)} = 2.0081816\text{E}-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_2 -

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

$$u = 2.0081816\text{E}-005$$

$$\text{Mu} = 4.6495\text{E}+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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: $c_u = 0.00595799$

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.24864441$$

$$Mu = MRc \text{ (4.14)} = 4.6495E+007$$

$$u = su \text{ (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

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

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

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

$$V_{Col0} = 302309.152$$

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

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).

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

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

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

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

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

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

$$s/d = 0.50$$

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

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

$$b_w = 500.00$$

Calculation of Shear Strength at edge 2, Vr2 = 302309.152

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 302309.152

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

M/Vd = 2.00

Mu = 6.1816411E-012

Vu = 7.3920505E-032

d = 0.8*h = 200.00

Nu = 4666.932

Ag = 125000.00

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

Av = 157079.633

fy = 525.00

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.50

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

From (11-11), ACI 440: Vs + Vf <= 363854.192

bw = 500.00

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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

Lap Length lo = 300.00

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15592384$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, 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

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.7831717E-006$

$M_u = 1.0928E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

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

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 stirrups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.22187159$$

$$Mu = MRc \text{ (4.14)} = 1.0928E+008$$

$$u = su \text{ (4.1)} = 8.7831717E-006$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_1 -

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

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

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.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

--->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$db = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of Mu_{2+}

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

$u = 8.7831717E-006$

$Mu = 1.0928E+008$

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

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

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

$w_e (5.4c) = 0.00377606$

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

$bo = 440.00$

$ho = 190.00$

$bi2 = 459400.00$

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

$psh,x (5.4d) = 0.00314159$

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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338
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 = 256.2112
with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755
2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755
v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$db = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$s = 100.00$

$n = 8.00$

 Calculation of Mu_2 -

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

$u = 8.7831717E-006$

$Mu = 1.0928E+008$

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

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 = 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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.03005942$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl, ten} / (b * d) * (f_{s1} / f_c) = 0.08730704$
 $2 = A_{sl, com} / (b * d) * (f_{s2} / f_c) = 0.08730704$
 $v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s, y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b / l_d

Lap Length: $l_b / l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 467242.766$
 $knl = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M / Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 * h = 400.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$

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, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -0.00055925$
Shear Force, $V2 = 3012.903$
Shear Force, $V3 = 2.6198972E-013$
Axial Force, $F = -4665.726$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 829.3805$
-Compression: $As_{c,com} = 829.3805$
-Middle: $As_{c,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^*$ $u = 0.00046874$
 $u = y + p = 0.00046874$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00046874$ ((4.29), Biskinis Phd))
 $My = 9.4271E+007$
 $Ls = M/V$ (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 y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.6045284E-006$
with ((10.1), ASCE 41-17) $fy = \text{Min}(fy, 1.25 * fy * (lb/d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806153$
 $A = 0.01821008$
 $B = 0.01003952$
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

Lap Length: $ld/d, \text{min} = 0.21819173$

$$l_b = 300.00$$

$$l_d = 1374.938$$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 525.00$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.15592384$

$$d = 457.00$$

$$s = 0.00$$

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

$A_v = 157.0796$, 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.

$$N_{UD} = 4665.726$$

$$A_g = 125000.00$$

$$f'_c E = 30.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

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

$$b = 250.00$$

$$d = 457.00$$

$$f'_c E = 30.00$$

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

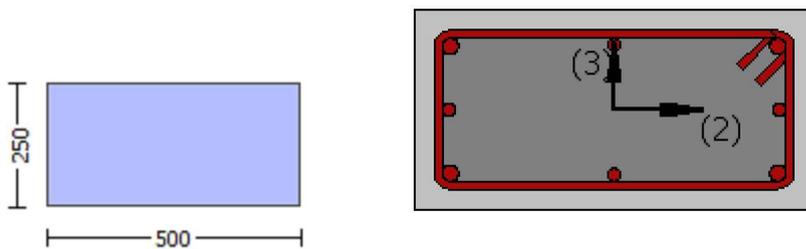
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

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

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

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

Shear Force, $V_a = -4751.50$
EDGE -B-
Bending Moment, $M_b = -0.00088196$
Shear Force, $V_b = 4751.50$
BOTH EDGES
Axial Force, $F = -4665.031$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{sc,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.66667$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 320061.918$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 320061.918$
 $V_{CoI} = 320061.918$
 $k_n = 1.00$
displacement_ductility_demand = 0.04165209

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

= 1 (normal-weight concrete)
 $f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1.4257E+007$
 $V_u = 4751.50$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4665.031$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 263893.783$
 $A_v = 157079.633$
 $f_y = 420.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 1.00$
 $s/d = 0.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 250.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation = 0.00019527
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00468824$ ((4.29), Biskinis Phd)
 $M_y = 9.4270E+007$
 $L_s = M/V$ (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
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c \cdot I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 3.6045267\text{E-}006$
with $((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806118$
 $A = 0.01821005$
 $B = 0.0100395$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $" = 0.0940919$
 $y_{\text{comp}} = 1.6615368\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_d, \text{min} = 0.21819173$
 $l_b = 300.00$
 $l_d = 1374.938$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

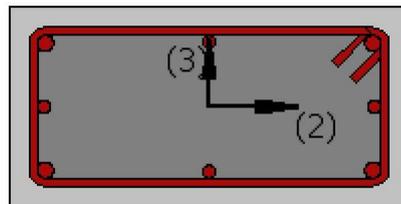
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

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: $As_{l,com} = 829.3805$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.10253309$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 4.6495E+007$

$M_{u1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 4.6495E+007$

$M_{u2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_{co} (5A.5, TBDY) = 0.002

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

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

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

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

$\phi_{psh,x}$ (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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 256.2112$$

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

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

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

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

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

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

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

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.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09095043$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09095043$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04409718$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.24864441

$\mu_u = M/R_c$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_u

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

$u = 2.0081816E-005$

$\mu_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

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

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

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

we (5.4c) = 0.00377606

ase ((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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.00097604$
 $sh_1 = 0.00312334$
 $ft_1 = 307.4535$
 $fy_1 = 256.2112$
 $su_1 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 256.2112$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00097604$
 $sh_2 = 0.00312334$
 $ft_2 = 307.4535$
 $fy_2 = 256.2112$
 $su_2 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.17455338$
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 256.2112$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00097604$
 $sh_v = 0.00312334$
 $ft_v = 307.4535$
 $fy_v = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 256.2112$
 with $Es_v = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.06843691$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.06843691$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.03318153$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.09095043$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.09095043$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04409718$$

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

--->

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

--->

$$s_u(4.9) = 0.24864441$$

$$M_u = M_{Rc}(4.14) = 4.6495E+007$$

$$u = s_u(4.1) = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2+

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

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

No stirrups, 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

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

$$\text{su (4.9)} = 0.24864441$$

$$M_u = M_{Rc} \text{ (4.14)} = 4.6495E+007$$

$$u = \text{su (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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: $c_u = 0.00595799$

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

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

$$su \text{ (4.9)} = 0.24864441$$

$$Mu = MRc \text{ (4.14)} = 4.6495E+007$$

$$u = su \text{ (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = 100.00$$

$$n = 8.00$$

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

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

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

$$V_{Col0} = 302309.152$$

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

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).

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

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

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

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

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

V_s is multiplied by $Col = 1.00$

$$s/d = 0.50$$

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

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

$$b_w = 500.00$$

Calculation of Shear Strength at edge 2, Vr2 = 302309.152

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 302309.152

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

M/Vd = 2.00

Mu = 6.1816411E-012

Vu = 7.3920505E-032

d = 0.8*h = 200.00

Nu = 4666.932

Ag = 125000.00

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

Av = 157079.633

fy = 525.00

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.50

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

From (11-11), ACI 440: Vs + Vf <= 363854.192

bw = 500.00

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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

Lap Length lo = 300.00

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15592384$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, 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

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.7831717E-006$

$M_u = 1.0928E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

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

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 stirrups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

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

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

$$su \text{ (4.9)} = 0.22187159$$

$$Mu = MRc \text{ (4.14)} = 1.0928E+008$$

$$u = su \text{ (4.1)} = 8.7831717E-006$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_1 -

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

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$bo = 440.00$$

$$ho = 190.00$$

$$bi_2 = 459400.00$$

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

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

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

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

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.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

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) = 0.08730704
2 = Asl,com/(b*d)*(fs2/fc) = 0.08730704
v = Asl,mid/(b*d)*(fsv/fc) = 0.04233068
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

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

--->
su (4.9) = 0.22187159
Mu = MRc (4.14) = 1.0928E+008
u = su (4.1) = 8.7831717E-006

Calculation of ratio lb/l_d

Lap Length: lb/l_d = 0.17455338

lb = 300.00

ld = 1718.672

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

db = 18.00

Mean strength value of all re-bars: fy = 656.25

fc' = 30.00, but fc^{0.5} <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 7.85398

Atr = Min(Atr_x,Atr_y) = 157.0796

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y local axis

s = 100.00

n = 8.00

Calculation of Mu₂₊

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

u = 8.7831717E-006

Mu = 1.0928E+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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338
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 = 256.2112
with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755
2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755
v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Mu_2 -

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

$u = 8.7831717E-006$
 $Mu = 1.0928E+008$

 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 : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00595799$
 $we (5.4c) = 0.00377606$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi_2 = 459400.00$
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00314159$

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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03005942$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$
 $V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = knl * V_{Co10}$
 $V_{Co10} = 467242.766$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 * h = 400.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$

Vs is multiplied by Col = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 363854.192
bw = 250.00

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

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

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

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

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

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length lb = 300.00
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 $u,R = 1.0^*$ $u = 0.03304406$

$u = y + p = 0.03304406$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00420468$ ((4.29), Biskinis Phd))

$M_y = 4.2282E+007$

$L_s = M/V$ (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 -

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

$y_{ten} = 8.2854850E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 237.8454$

$d = 207.00$

$y = 0.30661162$

$A = 0.02010143$

$B = 0.01221362$

with $p_t = 0.00801334$

$p_c = 0.00801334$

$p_v = 0.00388525$

$N = 4665.031$

$b = 500.00$

" = 0.20772947

$y_{comp} = 3.3230737E-005$

with $f_c = 30.00$

$E_c = 25742.96$

$y = 0.30494742$

$A = 0.01980449$

$B = 0.01202411$

with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Lap Length: $I_d / I_d, \text{min} = 0.21819173$

$$l_b = 300.00$$

$$l_d = 1374.938$$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 525.00$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

- Calculation of p -

From table 10-8: $p = 0.02883938$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.10253309$

$$d = 207.00$$

$$s = 0.00$$

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

$A_v = 157.0796$, 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.

$$N_{UD} = 4665.031$$

$$A_g = 125000.00$$

$$f'_c E = 30.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

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

$$b = 500.00$$

$$d = 207.00$$

$$f'_c E = 30.00$$

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

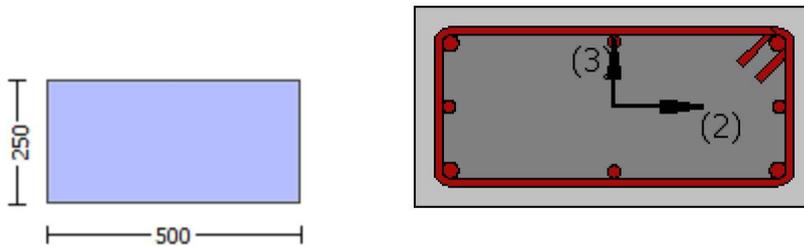
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

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

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

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

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

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: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 829.3805$
-Compression: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

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)
 $M/Vd = 2.00$
 $\mu_u = 1.1221826E-009$
 $V_u = 4.1317099E-013$
 $d = 0.8 \cdot h = 200.00$
 $N_u = 4665.031$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 131946.891$
 $A_v = 157079.633$
 $f_y = 420.00$
 $s = 100.00$
 V_s is multiplied by $Col = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 500.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 5.8795680E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00420468$ ((4.29), Biskinis Phd)
 $M_y = 4.2282E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 8.2854850\text{E}-006$
with $((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 237.8454$
 $d = 207.00$
 $y = 0.30661162$
 $A = 0.02010143$
 $B = 0.01221362$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.031$
 $b = 500.00$
 $" = 0.20772947$
 $y_{\text{comp}} = 3.3230737\text{E}-005$
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

Lap Length: $l_d/l_d, \text{min} = 0.21819173$
 $l_b = 300.00$
 $l_d = 1374.938$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

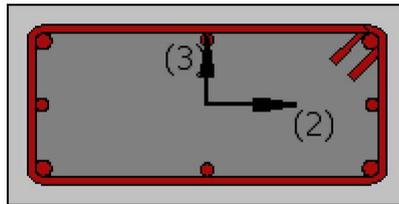
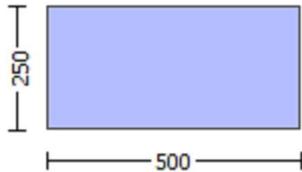
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

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

Lap Length $l_o = 300.00$

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: $As_{l,com} = 829.3805$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.10253309$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$

with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 4.6495E+007$
 $M_{u1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 4.6495E+007$

$M_{u2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

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

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

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

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

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

$\phi_{psh,x}$ (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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 256.2112$$

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

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

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

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

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

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

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

$$lo/lou,min = lb/ld = 0.17455338$$

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

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.

$$\text{with } fsv = fs = 256.2112$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

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

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09095043$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09095043$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04409718$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.24864441

$M_u = M_{Rc}$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_{u1} -

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

$u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

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

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

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

we (5.4c) = 0.00377606

ase ((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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.00097604$
 $sh_1 = 0.00312334$
 $ft_1 = 307.4535$
 $fy_1 = 256.2112$
 $su_1 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 256.2112$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00097604$
 $sh_2 = 0.00312334$
 $ft_2 = 307.4535$
 $fy_2 = 256.2112$
 $su_2 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.17455338$
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 256.2112$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00097604$
 $sh_v = 0.00312334$
 $ft_v = 307.4535$
 $fy_v = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 256.2112$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.06843691$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.06843691$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.03318153$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.09095043$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.09095043$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04409718$$

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

--->

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

--->

$$s_u(4.9) = 0.24864441$$

$$M_u = M_{Rc}(4.14) = 4.6495E+007$$

$$u = s_u(4.1) = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2+

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e(5.4c) = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

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

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

No stirrups, 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

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

--->
 μ_u (4.9) = 0.24864441
 $M_u = M_{Rc}$ (4.14) = 4.6495E+007
 $u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of μ_u

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

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

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

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

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

$$\mu_w$$
 (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, $n_s = 2.00$

$$b_k = 500.00$$

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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

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

--->

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

--->

$$su \text{ (4.9)} = 0.24864441$$

$$Mu = MRc \text{ (4.14)} = 4.6495E+007$$

$$u = su \text{ (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = 100.00$$

$$n = 8.00$$

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

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

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

$$V_{Col0} = 302309.152$$

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

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).

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

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

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

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

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

V_s is multiplied by $Col = 1.00$

$$s/d = 0.50$$

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

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

$$b_w = 500.00$$

Calculation of Shear Strength at edge 2, Vr2 = 302309.152

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 302309.152

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

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

M/Vd = 2.00

Mu = 6.1816411E-012

Vu = 7.3920505E-032

d = 0.8*h = 200.00

Nu = 4666.932

Ag = 125000.00

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

Av = 157079.633

fy = 525.00

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.50

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

From (11-11), ACI 440: Vs + Vf <= 363854.192

bw = 500.00

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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

Lap Length lo = 300.00

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15592384$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, 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

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.7831717E-006$

$M_u = 1.0928E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_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: $\phi_u = 0.00595799$

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 stirrups, $n_s = 2.00$

$b_k = 500.00$

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

s = 100.00
fywe = 656.25
fce = 30.00

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

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$$su \text{ (4.9)} = 0.22187159$$

$$Mu = MRc \text{ (4.14)} = 1.0928E+008$$

$$u = su \text{ (4.1)} = 8.7831717E-006$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_1 -

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

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

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

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

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

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

$$w_e \text{ (5.4c)} = 0.00377606$$

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

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

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

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

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

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

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.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

--->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $fc' = 30.00$, but $fc'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$
 where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.7831717E-006$
 $Mu = 1.0928E+008$

 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 : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00595799$
 $we (5.4c) = 0.00377606$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi2 = 459400.00$
 $psh, \text{min} = \text{Min}(psh,x, psh,y) = 0.00314159$

 $psh,x (5.4d) = 0.00314159$

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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338
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 = 256.2112
with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755
2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755
v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$db = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$s = 100.00$

$n = 8.00$

 Calculation of Mu_2 -

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

$u = 8.7831717E-006$

$Mu = 1.0928E+008$

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

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

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

$we (5.4c) = 0.00377606$

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

$bo = 440.00$

$ho = 190.00$

$bi_2 = 459400.00$

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

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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

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

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

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

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03005942$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/d

Lap Length: $l_b/d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$
 $V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = knl * V_{Co1}$
 $V_{Co1} = 467242.766$
 $knl = 1$ (zero step-static loading)

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

 $= 1$ (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 3.6217549E-012$
 $Vu = 4.5261760E-048$
 $d = 0.8 * h = 400.00$
 $Nu = 4666.932$
 $Ag = 125000.00$
 From (11.5.4.8), ACI 318-14: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$

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: (a)
Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.4257E+007$
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: $A_{st,ten} = 829.3805$
-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 $u,R = 1.0^*$ $u = 0.04668824$
 $u = y + p = 0.04668824$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00468824$ ((4.29), Biskinis Phd))
 $M_y = 9.4270E+007$
 $L_s = M/V$ (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 y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.6045267E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806118$
 $A = 0.01821005$
 $B = 0.0100395$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $" = 0.0940919$
 $y_{comp} = 1.6615368E-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_d, \text{min} = 0.21819173$

$$l_b = 300.00$$

$$l_d = 1374.938$$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d , min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 525.00$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

- Calculation of p -

From table 10-8: $p = 0.042$

with:

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

shear control ratio $V_y E / V_{CoI} E = 0.15592384$

$$d = 457.00$$

$$s = 0.00$$

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

$A_v = 157.0796$, 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.

$$N_{UD} = 4665.031$$

$$A_g = 125000.00$$

$$f'_c E = 30.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

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

$$b = 250.00$$

$$d = 457.00$$

$$f'_c E = 30.00$$

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

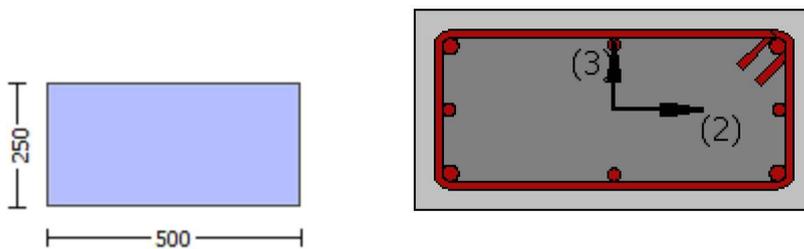
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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, $\gamma = 1.00$

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

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

Consequently:

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

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

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.4257E+007$

Shear Force, $V_a = -4751.50$
EDGE -B-
Bending Moment, $M_b = -0.00088196$
Shear Force, $V_b = 4751.50$
BOTH EDGES
Axial Force, $F = -4665.031$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 829.3805$
-Compression: $A_{sc,com} = 829.3805$
-Middle: $A_{st,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 18.66667$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 376230.054$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 376230.054$
 $V_{CoI} = 376230.054$
 $k_n = 1.00$
displacement_ductility_demand = 0.22683304

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
 $f_c' = 20.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 0.00088196$
 $V_u = 4751.50$
 $d = 0.8 \cdot h = 400.00$
 $N_u = 4665.031$
 $A_g = 125000.00$
From (11.5.4.8), ACI 318-14: $V_s = 263893.783$
 $A_v = 157079.633$
 $f_y = 420.00$
 $s = 100.00$
 V_s is multiplied by $CoI = 1.00$
 $s/d = 0.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 250.00$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 0.00010632
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00046873$ ((4.29), Biskinis Phd)
 $M_y = 9.4270E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.0112E+013$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c \cdot I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 3.6045267\text{E-}006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806118$
 $A = 0.01821005$
 $B = 0.0100395$
with $p_t = 0.00725935$
 $p_c = 0.00725935$
 $p_v = 0.00351968$
 $N = 4665.031$
 $b = 250.00$
 $" = 0.0940919$
 $y_{\text{comp}} = 1.6615368\text{E-}005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b/d

Lap Length: $l_d/d, \text{min} = 0.21819173$
 $l_b = 300.00$
 $l_d = 1374.938$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

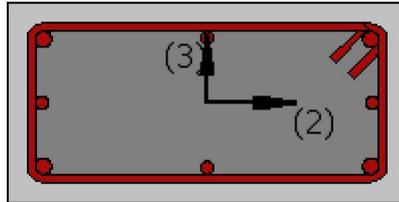
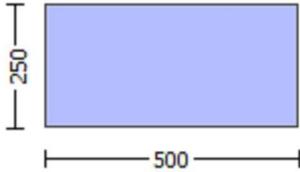
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 525.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

New material: Steel Strength, $f_s = 1.25 * f_{sm} = 656.25$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.04002

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

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: $As_{,ten} = 829.3805$

-Compression: $As_{,com} = 829.3805$

-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.10253309$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$

with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 4.6495E+007$
 $M_{u1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 4.6495E+007$

$M_{u2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

$\phi_{psh,x}$ (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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 256.2112$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.17455338$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fsv = fs = 256.2112$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09095043$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09095043$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04409718$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

--->

μ_u (4.9) = 0.24864441

$M_u = M_{Rc}$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

$f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.00595799$

we (5.4c) = 0.00377606

ase ((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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.00097604$
 $sh_1 = 0.00312334$
 $ft_1 = 307.4535$
 $fy_1 = 256.2112$
 $su_1 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 256.2112$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00097604$
 $sh_2 = 0.00312334$
 $ft_2 = 307.4535$
 $fy_2 = 256.2112$
 $su_2 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.17455338$
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 256.2112$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00097604$
 $sh_v = 0.00312334$
 $ft_v = 307.4535$
 $fy_v = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv \text{ nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 256.2112$
 with $Es_v = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.06843691$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.06843691$
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.03318153$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.09095043$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.09095043$

$$v = A_{sl, mid} / (b * d) * (f_{sv} / f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture
satisfies Eq. (4.3)

--->

$v < v_{s, y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.24864441$$

$$M_u = M_{Rc}(4.14) = 4.6495E+007$$

$$u = s_u(4.1) = 2.0081816E-005$$

Calculation of ratio l_b / l_d

Lap Length: $l_b / l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr, x}, A_{tr, y}) = 157.0796$$

where $A_{tr, x}$, $A_{tr, y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

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, 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture
satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->
 μ_u (4.9) = 0.24864441
 $M_u = M_{Rc}$ (4.14) = 4.6495E+007
 $u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f'_c = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of μ_u

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.00595799$

$$\omega_e \text{ (5.4c)} = 0.00377606$$

$$\omega_{ase} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00314159$$

$$\mu_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 656.25
fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

$$cc \text{ (5A.5, TBDY)} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$su \text{ (4.9)} = 0.24864441$$

$$Mu = MRc \text{ (4.14)} = 4.6495E+007$$

$$u = su \text{ (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$$

$$V_{Col0} = 302309.152$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 164933.614$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

$$V_s \text{ is multiplied by } Col = 1.00$$

$$s/d = 0.50$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 363854.192$$

$$b_w = 500.00$$

Calculation of Shear Strength at edge 2, Vr2 = 302309.152

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 302309.152

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 30.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 6.1816411E-012

Vu = 7.3920505E-032

d = 0.8*h = 200.00

Nu = 4666.932

Ag = 125000.00

From (11.5.4.8), ACI 318-14: Vs = 164933.614

Av = 157079.633

fy = 525.00

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.50

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 363854.192

bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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

Lap Length lo = 300.00

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15592384$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.7831717E-006$

$M_u = 1.0928E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_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: $\phi_u = 0.00595799$

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 stirrups, $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 656.25
fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

$$cc \text{ (5A.5, TBDY)} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$$su \text{ (4.9)} = 0.22187159$$

$$Mu = MRc \text{ (4.14)} = 1.0928E+008$$

$$u = su \text{ (4.1)} = 8.7831717E-006$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$w_e \text{ (5.4c)} = 0.00377606$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

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.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

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) = 0.08730704
2 = Asl,com/(b*d)*(fs2/fc) = 0.08730704
v = Asl,mid/(b*d)*(fsv/fc) = 0.04233068
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
su (4.9) = 0.22187159
Mu = MRc (4.14) = 1.0928E+008
u = su (4.1) = 8.7831717E-006

Calculation of ratio lb/l_d

Lap Length: lb/l_d = 0.17455338
lb = 300.00
l_d = 1718.672

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
l_{d,min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1
db = 18.00
Mean strength value of all re-bars: fy = 656.25
fc' = 30.00, but fc^{0.5} <= 8.3 MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 7.85398
Atr = Min(Atr_x,Atr_y) = 157.0796
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y local axis
s = 100.00
n = 8.00

Calculation of Mu₂₊

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 8.7831717E-006
Mu = 1.0928E+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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338
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 = 256.2112
with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755
2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755
v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Mu_2 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 8.7831717E-006$
 $Mu = 1.0928E+008$

 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 : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 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 = 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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03005942$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/d

 Lap Length: $l_b/d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

 Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 467242.766$
 $knl = 1$ (zero step-static loading)

 NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ 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: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$

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, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 1.1815160E-010$

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: $A_{st,ten} = 829.3805$

-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 $u,R = 1.0^*$ $u = 0.03304406$

$u = y + p = 0.03304406$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00420468$ ((4.29), Biskinis Phd))

$M_y = 4.2282E+007$

$L_s = M/V$ (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 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 8.2854850E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 237.8454$

$d = 207.00$

$y = 0.30661162$

$A = 0.02010143$

$B = 0.01221362$

with $p_t = 0.00801334$

$p_c = 0.00801334$

$p_v = 0.00388525$

$N = 4665.031$

$b = 500.00$

" = 0.20772947

$y_{comp} = 3.3230737E-005$

with $f_c = 30.00$

$E_c = 25742.96$

$y = 0.30494742$

$A = 0.01980449$

$B = 0.01202411$

with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Lap Length: $I_d / I_d, \text{min} = 0.21819173$

$$l_b = 300.00$$

$$l_d = 1374.938$$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 525.00$

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

- Calculation of p -

From table 10-8: $p = 0.02883938$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{col} O E = 0.10253309$

$$d = 207.00$$

$$s = 0.00$$

$$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$$

$A_v = 157.0796$, 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.

$$N_{UD} = 4665.031$$

$$A_g = 125000.00$$

$$f'_c E = 30.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

$$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.01991193$$

$$b = 500.00$$

$$d = 207.00$$

$$f'_c E = 30.00$$

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

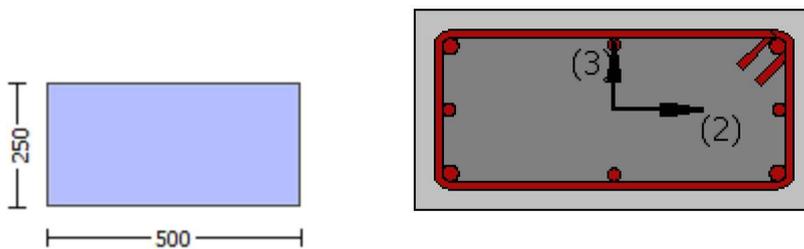
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

New material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 20.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 420.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE41-17).

New material: Concrete Strength, $f_c = f_{cm} = 30.00$

New material: Steel Strength, $f_s = f_{sm} = 525.00$

#####

Section Height, $H = 250.00$

Section Width, $W = 500.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

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: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 829.3805$
-Compression: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 18.66667$

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 $CoI = 1.00$
 $s/d = 0.50$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 297085.704$
 $bw = 500.00$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 2.6253864E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00420468$ ((4.29), Biskinis Phd)
 $M_y = 4.2282E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 5.0279E+012$
factor = 0.30
 $A_g = 125000.00$
 $f_c' = 30.00$
 $N = 4665.031$
 $E_c \cdot I_g = 1.6760E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 8.2854850\text{E}-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 237.8454$
 $d = 207.00$
 $y = 0.30661162$
 $A = 0.02010143$
 $B = 0.01221362$
with $p_t = 0.00801334$
 $p_c = 0.00801334$
 $p_v = 0.00388525$
 $N = 4665.031$
 $b = 500.00$
 $" = 0.20772947$
 $y_{\text{comp}} = 3.3230737\text{E}-005$
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

Lap Length: $l_d/l_d, \text{min} = 0.21819173$
 $l_b = 300.00$
 $l_d = 1374.938$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $d_b = 18.00$
Mean strength value of all re-bars: $f_y = 525.00$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

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

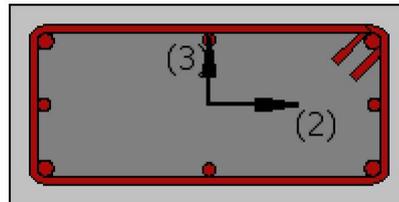
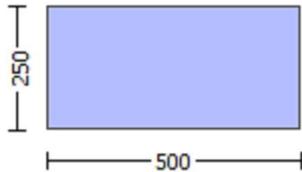
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

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

Lap Length $l_o = 300.00$

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: $As_{,ten} = 829.3805$

-Compression: $As_{,com} = 829.3805$

-Middle: $As_{,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.10253309$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 30996.691$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 4.6495E+007$

$M_{u1+} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 4.6495E+007$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 4.6495E+007$

$M_{u2+} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 4.6495E+007$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 2.0081816E-005$

$M_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

ϕ_{co} (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00595799$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.00595799$

ϕ_{we} (5.4c) = 0.00377606

ϕ_{ase} ((5.4d), TBDY) = 0.05494666

$b_o = 440.00$

$h_o = 190.00$

$b_{i2} = 459400.00$

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00314159$

$\phi_{psh,x}$ (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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$

$$fywe = 656.25$$

$$fce = 30.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$

$$c = \text{confinement factor} = 1.04002$$

$$y1 = 0.00097604$$

$$sh1 = 0.00312334$$

$$ft1 = 307.4535$$

$$fy1 = 256.2112$$

$$su1 = 0.00312334$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.17455338$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 256.2112$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00097604$$

$$sh2 = 0.00312334$$

$$ft2 = 307.4535$$

$$fy2 = 256.2112$$

$$su2 = 0.00312334$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.17455338$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = fs = 256.2112$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00097604$$

$$shv = 0.00312334$$

$$ftv = 307.4535$$

$$fyv = 256.2112$$

$$suv = 0.00312334$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 0.17455338$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fsv = fs = 256.2112$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153$$

and confined core properties:

$$b = 440.00$$

$$d = 177.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 31.20058$$

$$cc (5A.5, TBDY) = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09095043$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09095043$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04409718$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

$v < v_s, y_2$ - LHS eq.(4.5) is satisfied

--->

μ_u (4.9) = 0.24864441

$\mu_u = M/R_c$ (4.14) = 4.6495E+007

$u = \mu_u$ (4.1) = 2.0081816E-005

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$

$l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

$d_b = 18.00$

Mean strength value of all re-bars: $f_y = 656.25$

$f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 7.85398$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$

where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = 100.00$

$n = 8.00$

Calculation of μ_u

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$u = 2.0081816E-005$

$\mu_u = 4.6495E+007$

with full section properties:

$b = 500.00$

$d = 207.00$

$d' = 43.00$

$v = 0.00150304$

$N = 4666.932$

$f_c = 30.00$

α (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00595799$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.00595799$

we (5.4c) = 0.00377606

ase ((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, $n_s = 2.00$

$b_k = 250.00$

$s = 100.00$
 $fy_{we} = 656.25$
 $f_{ce} = 30.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $y_1 = 0.00097604$
 $sh_1 = 0.00312334$
 $ft_1 = 307.4535$
 $fy_1 = 256.2112$
 $su_1 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 256.2112$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00097604$
 $sh_2 = 0.00312334$
 $ft_2 = 307.4535$
 $fy_2 = 256.2112$
 $su_2 = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.17455338$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 256.2112$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00097604$
 $sh_v = 0.00312334$
 $ft_v = 307.4535$
 $fy_v = 256.2112$
 $suv = 0.00312334$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 0.17455338$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 256.2112$
 with $Es_v = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1 / fc) = 0.06843691$
 $2 = Asl, \text{com}/(b * d) * (fs_2 / fc) = 0.06843691$
 $v = Asl, \text{mid}/(b * d) * (fsv / fc) = 0.03318153$
 and confined core properties:
 $b = 440.00$
 $d = 177.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 31.20058$
 $cc \text{ (5A.5, TBDY)} = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = Asl, \text{ten}/(b * d) * (fs_1 / fc) = 0.09095043$
 $2 = Asl, \text{com}/(b * d) * (fs_2 / fc) = 0.09095043$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s, y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.24864441$$

$$M_u = M_{Rc}(4.14) = 4.6495E+007$$

$$u = s_u(4.1) = 2.0081816E-005$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b, min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr, x}, A_{tr, y}) = 157.0796$$

where $A_{tr, x}$, $A_{tr, y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of M_u2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 2.0081816E-005$$

$$M_u = 4.6495E+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} \cdot \text{Max}(c_u, c_c) = 0.00595799$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00595799$$

$$w_e(5.4c) = 0.00377606$$

$$a_{se}((5.4d), TBDY) = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh, min} = \text{Min}(p_{sh, x}, p_{sh, y}) = 0.00314159$$

$$p_{sh, x}(5.4d) = 0.00314159$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

$$p_{sh, y}(5.4d) = 0.00628319$$

$$A_{sh} = A_{stir} \cdot n_s = 78.53982$$

No stirrups, 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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture
satisfies Eq. (4.3)

--->
v < v_{s,y2} - LHS eq.(4.5) is satisfied

$$\text{su (4.9)} = 0.24864441$$

$$\text{Mu} = \text{MRc (4.14)} = 4.6495\text{E}+007$$

$$u = \text{su (4.1)} = 2.0081816\text{E}-005$$

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.17455338

$$lb = 300.00$$

$$ld = 1718.672$$

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$db = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 2.0081816\text{E}-005$$

$$\text{Mu} = 4.6495\text{E}+007$$

with full section properties:

$$b = 500.00$$

$$d = 207.00$$

$$d' = 43.00$$

$$v = 0.00150304$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

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: $c_u = 0.00595799$

$$w_e \text{ (5.4c)} = 0.00377606$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

No stirrups, $n_s = 2.00$

$$b_k = 500.00$$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 656.25
fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06843691

2 = Asl,com/(b*d)*(fs2/fc) = 0.06843691

v = Asl,mid/(b*d)*(fsv/fc) = 0.03318153

and confined core properties:

b = 440.00

d = 177.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

$$cc \text{ (5A.5, TBDY)} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09095043$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09095043$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04409718$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$$su \text{ (4.9)} = 0.24864441$$

$$Mu = MRc \text{ (4.14)} = 4.6495E+007$$

$$u = su \text{ (4.1)} = 2.0081816E-005$$

Calculation of ratio l_b/l_d

$$\text{Lap Length: } l_b/l_d = 0.17455338$$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 302309.152$

Calculation of Shear Strength at edge 1, $V_{r1} = 302309.152$

$$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$$

$$V_{Col0} = 302309.152$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 6.1816411E-012$$

$$Vu = 7.3920505E-032$$

$$d = 0.8 * h = 200.00$$

$$Nu = 4666.932$$

$$Ag = 125000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = 164933.614$$

$$A_v = 157079.633$$

$$f_y = 525.00$$

$$s = 100.00$$

$$V_s \text{ is multiplied by } Col = 1.00$$

$$s/d = 0.50$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 363854.192$$

$$b_w = 500.00$$

Calculation of Shear Strength at edge 2, Vr2 = 302309.152

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 302309.152

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

fc' = 30.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 6.1816411E-012

Vu = 7.3920505E-032

d = 0.8*h = 200.00

Nu = 4666.932

Ag = 125000.00

From (11.5.4.8), ACI 318-14: Vs = 164933.614

Av = 157079.633

fy = 525.00

s = 100.00

Vs is multiplied by Col = 1.00

s/d = 0.50

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 363854.192

bw = 500.00

End Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column C1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00

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

Lap Length lo = 300.00

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: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.15592384$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 72854.286$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.0928E+008$

$Mu_{1+} = 1.0928E+008$, 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

$Mu_{1-} = 1.0928E+008$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.0928E+008$

$Mu_{2+} = 1.0928E+008$, 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

$Mu_{2-} = 1.0928E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.7831717E-006$

$M_u = 1.0928E+008$

with full section properties:

$b = 250.00$

$d = 457.00$

$d' = 43.00$

$v = 0.00136161$

$N = 4666.932$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00595799$

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 stirrups, $n_s = 2.00$

$b_k = 500.00$

psh,y (5.4d) = 0.00628319
Ash = Astir*ns = 78.53982
No stirups, ns = 2.00
bk = 250.00

s = 100.00
fywe = 656.25
fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.00240019
c = confinement factor = 1.04002

y1 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535
fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

b = 190.00

d = 427.00

d' = 13.00

fcc (5A.2, TBDY) = 31.20058

$$cc \text{ (5A.5, TBDY)} = 0.00240019$$

$$c = \text{confinement factor} = 1.04002$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

$$su \text{ (4.9)} = 0.22187159$$

$$Mu = MRc \text{ (4.14)} = 1.0928E+008$$

$$u = su \text{ (4.1)} = 8.7831717E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.17455338$

$$l_b = 300.00$$

$$l_d = 1718.672$$

Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 656.25$

$$f_c' = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.7831717E-006$$

$$Mu = 1.0928E+008$$

with full section properties:

$$b = 250.00$$

$$d = 457.00$$

$$d' = 43.00$$

$$v = 0.00136161$$

$$N = 4666.932$$

$$f_c = 30.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.00595799$$

$$w_e \text{ (5.4c)} = 0.00377606$$

$$a_{se} \text{ ((5.4d), TBDY)} = 0.05494666$$

$$b_o = 440.00$$

$$h_o = 190.00$$

$$b_{i2} = 459400.00$$

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00314159$$

$$p_{sh,x} \text{ (5.4d)} = 0.00314159$$

$$A_{sh} = A_{stir} * n_s = 78.53982$$

$$\text{No stirups, } n_s = 2.00$$

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.A5), TBDY), TBDY: cc = 0.00240019

c = confinement factor = 1.04002

y1 = 0.00097604

sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

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) = 0.08730704
2 = Asl,com/(b*d)*(fs2/fc) = 0.08730704
v = Asl,mid/(b*d)*(fsv/fc) = 0.04233068
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->
v < vs,y2 - LHS eq.(4.5) is satisfied

--->
su (4.9) = 0.22187159
Mu = MRc (4.14) = 1.0928E+008
u = su (4.1) = 8.7831717E-006

Calculation of ratio lb/l_d

Lap Length: lb/l_d = 0.17455338

lb = 300.00

l_d = 1718.672

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_{d,min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

= 1

db = 18.00

Mean strength value of all re-bars: fy = 656.25

fc' = 30.00, but fc^{0.5} <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 7.85398

Atr = Min(Atr_x,Atr_y) = 157.0796

where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y local axis

s = 100.00

n = 8.00

Calculation of Mu₂₊

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.7831717E-006

Mu = 1.0928E+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 = 0.00097604
sh1 = 0.00312334
ft1 = 307.4535
fy1 = 256.2112
su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Es1 = Es = 200000.00

y2 = 0.00097604
sh2 = 0.00312334
ft2 = 307.4535
fy2 = 256.2112
su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338
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 = 256.2112
with Es2 = Es = 200000.00

yv = 0.00097604
shv = 0.00312334
ftv = 307.4535
fyv = 256.2112
suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338
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 = 256.2112
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755
2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755
v = Asl,mid/(b*d)*(fsv/fc) = 0.03005942

and confined core properties:

$b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.17455338$

$l_b = 300.00$
 $l_d = 1718.672$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 157.0796$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Mu_2 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 8.7831717E-006$
 $Mu = 1.0928E+008$

 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 : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00595799$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00595799$
 $we (5.4c) = 0.00377606$
 $ase ((5.4d), TBDY) = 0.05494666$
 $bo = 440.00$
 $ho = 190.00$
 $bi_2 = 459400.00$
 $psh, \min = \text{Min}(psh,x, psh,y) = 0.00314159$

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 = 0.00097604
sh1 = 0.00312334

ft1 = 307.4535

fy1 = 256.2112

su1 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Es1 = Es = 200000.00

y2 = 0.00097604

sh2 = 0.00312334

ft2 = 307.4535

fy2 = 256.2112

su2 = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.17455338

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 = 256.2112

with Es2 = Es = 200000.00

yv = 0.00097604

shv = 0.00312334

ftv = 307.4535

fyv = 256.2112

suv = 0.00312334

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.17455338

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 = 256.2112

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.06199755

2 = Asl,com/(b*d)*(fs2/fc) = 0.06199755

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.03005942$
 and confined core properties:
 $b = 190.00$
 $d = 427.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 31.20058$
 $cc (5A.5, TBDY) = 0.00240019$
 $c = \text{confinement factor} = 1.04002$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.08730704$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08730704$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04233068$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.22187159$
 $Mu = MRc (4.14) = 1.0928E+008$
 $u = su (4.1) = 8.7831717E-006$

 Calculation of ratio l_b/d

 Lap Length: $l_b/d = 0.17455338$
 $l_b = 300.00$
 $l_d = 1718.672$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 18.00$
 Mean strength value of all re-bars: $f_y = 656.25$
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 7.85398$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = 100.00$
 $n = 8.00$

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 467242.766$

 Calculation of Shear Strength at edge 1, $V_{r1} = 467242.766$
 $V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = knl * V_{Co1}$
 $V_{Co1} = 467242.766$
 $knl = 1$ (zero step-static loading)

 NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
 $f_c' = 30.00$, but $f_c'^{0.5} \leq 8.3$ 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: $V_s = 329867.229$
 $A_v = 157079.633$
 $f_y = 525.00$
 $s = 100.00$

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: 3
Integration Section: (b)
Section Type: rcrs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
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
Lap Length lb = 300.00
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: $As_{lt} = 0.00$
-Compression: $As_{lc} = 2060.885$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{l,ten} = 829.3805$
-Compression: $As_{l,com} = 829.3805$
-Middle: $As_{l,mid} = 402.1239$
Mean Diameter of Tension Reinforcement, $DbL = 18.66667$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.04246873$
 $u = y + p = 0.04246873$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00046873$ ((4.29), Biskinis Phd))
 $M_y = 9.4270E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.0112E+013$
 $factor = 0.30$
 $Ag = 125000.00$
 $fc' = 30.00$
 $N = 4665.031$
 $E_c * I_g = 6.7039E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.6045267E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 237.8454$
 $d = 457.00$
 $y = 0.27806118$
 $A = 0.01821005$
 $B = 0.0100395$
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 $fc = 30.00$
 $E_c = 25742.96$
 $y = 0.27625433$
 $A = 0.01794105$
 $B = 0.00986782$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_{d,min} = 0.21819173$

$$l_b = 300.00$$

$$l_d = 1374.938$$

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

$l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$$= 1$$

$$d_b = 18.00$$

Mean strength value of all re-bars: $f_y = 525.00$

$f'_c = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 7.85398$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 157.0796$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$$s = 100.00$$

$$n = 8.00$$

- Calculation of p -

From table 10-8: $p = 0.042$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_y E / V_{col} O E = 0.15592384$

$$d = 457.00$$

$$s = 0.00$$

$$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$$

$A_v = 157.0796$, 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.

$$N_{UD} = 4665.031$$

$$A_g = 125000.00$$

$$f'_c E = 30.00$$

$$f_{yt} E = f_{yl} E = 0.00$$

$$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.01803838$$

$$b = 250.00$$

$$d = 457.00$$

$$f'_c E = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column C1 of floor 1

At local axis: 3

Integration Section: (b)