

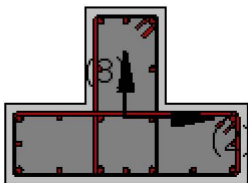
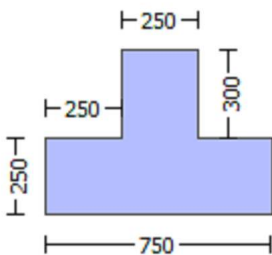
Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

- column C1, Floor 1
- Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)
- Analysis: Uniform +X
- Check: Shear capacity VRd
- Edge: Start
- Local Axis: (2)



- Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
- At local axis: 2
- Integration Section: (a)
- Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$
- New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
- Concrete Elasticity, $E_c = 28781.504$

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, $f_c = f_{cm} = 37.50$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

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Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3835E+007$

Shear Force, $V_a = -4487.046$

EDGE -B-

Bending Moment, $M_b = 370595.336$

Shear Force, $V_b = 4487.046$

BOTH EDGES

Axial Force, $F = -10860.955$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1231.504$

-Compression: $A_{st,com} = 1231.504$

-Middle: $A_{st,mid} = 2689.203$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.60$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 513376.601$

V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoI0} = 513376.601$

$V_{CoI} = 513376.601$

$k_n l = 1.00$

displacement_ductility_demand = 0.00738073

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

= 1 (normal-weight concrete)

$f'_c = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 1.3835E+007$

$V_u = 4487.046$

$d = 0.8 \cdot h = 600.00$

$N_u = 10860.955$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 104719.755$ is calculated for section web, with:

$d = 200.00$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 150.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.75$$

Vs2 = 314159.265 is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 150.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.25$$

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

From (11-11), ACI 440: Vs + Vf <= 498227.872

$$b_w = 250.00$$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END A -

for rotation axis 3 and integ. section (a)

From analysis, chord rotation = 7.5727826E-005

$$y = (M_y * L_s / 3) / E_{eff} = 0.01026021 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 7.9125E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3083.371$$

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 7.9262E+013$

$$\text{factor} = 0.30$$

$$A_g = 262500.00$$

$$f_c' = 37.50$$

$$N = 10860.955$$

$$E_c * I_g = 2.6421E+014$$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

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

$$y_{ten} = 6.3530147E-006$$

with $f_y = 625.00$

$$d = 707.00$$

$$y = 0.30425395$$

$$A = 0.02924803$$

$$B = 0.01555962$$

with $p_t = 0.00696749$

$$p_c = 0.00696749$$

$$p_v = 0.01521473$$

$$N = 10860.955$$

$$b = 250.00$$

$$r = 0.06082037$$

$$y_{comp} = 1.0916788E-005$$

with $f_c = 37.50$

$$E_c = 28781.504$$

$$y = 0.30386172$$

$$A = 0.02901871$$

$$B = 0.01546131$$

with $E_s = 200000.00$

Calculation of ratio I_b/I_d

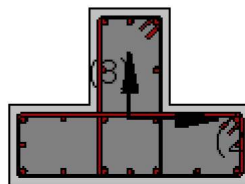
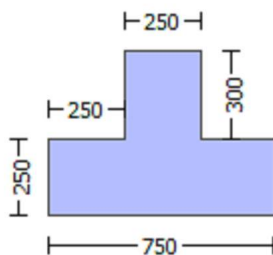
Adequate Lap Length: $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2
Integration Section: (a)

Calculation No. 2

column C1, Floor 1
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Chord rotation capacity (ϕ)
Edge: Start
Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

Steel Elasticity, $E_s = 200000.00$

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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, $f_s = 1.25 \cdot f_{sm} = 781.25$

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Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min > 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 0.00014703$
EDGE -B-
Shear Force, $V_b = -0.00014703$
BOTH EDGES
Axial Force, $F = -9867.326$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 2261.947$
-Compression: $A_{st,com} = 829.3805$
-Middle: $A_{st,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.35949$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.0273E+009$
 $\mu_{u1+} = 1.0273E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 7.8532E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.0273E+009$
 $\mu_{u2+} = 1.0273E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 7.8532E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 1.5224730E-005$
 $\mu_u = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$
 $f_c = 37.50$
 $\alpha_1(5A_s, \text{TB DY}) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha_1) = 0.00860501$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TB DY: $\mu_u = 0.00860501$
we (5.4c) = 0.01628822

$$ase = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$$

$$psh,x \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$psh,y \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 937.50$$

$$fy1 = 781.25$$

$$su1 = 0.032$$

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

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

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

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

$$\text{with } fs1 = fs = 781.25$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 937.50$$

$$fy2 = 781.25$$

$$su2 = 0.032$$

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

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

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

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

$$\text{with } fs2 = fs = 781.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 937.50$$

$$fy_v = 781.25$$

$$su_v = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 781.25$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.37178611$
 $2 = Asl_{com}/(b*d) * (fs2/fc) = 0.13632157$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.33873846$
and confined core properties:
 $b = 190.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.51995906$
 $2 = Asl_{com}/(b*d) * (fs2/fc) = 0.19065166$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.47374048$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < vs_{y2}$ - LHS eq.(4.5) is not satisfied
--->
 $v < vs_c$ - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
--->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
--->
 $cu (4.10) = 0.38433228$
 $MRC (4.17) = 9.9628E+008$
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
- $N, 1, 2, v$ normalised to $bo*do$, instead of $b*d$
- fcc, cc used in lieu of fc, ec
--->
Subcase: Rupture of tension steel
--->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
--->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is not satisfied
--->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is satisfied
--->
 $*cu (4.10) = 0.46822902$
 $MRO (4.17) = 1.0273E+009$
--->
 $u = cu (4.2) = 1.5224730E-005$

Mu = M_{Ro}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

$\phi_u = 7.1537995E-005$

Mu = 7.8532E+008

with full section properties:

b = 750.00

d = 507.00

d' = 43.00

$\nu = 0.00069199$

N = 9867.326

f_c = 37.50

$\phi_{0.5A.5, TB DY} = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00860501$

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

From (5.4b), TB DY: $\phi_u = 0.00860501$

$\phi_{0.5A.5} = 0.01628822$

$\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max} = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

A_{conf,min} = 110400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max} by a length equal to half the clear spacing between hoops.

A_{noConf} = 95733.333 is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$

$\phi_{psh,x} ((5.4d), TB DY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\phi_{psh,y} ((5.4d), TB DY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

s = 150.00

f_{ywe} = 781.25

f_{ce} = 37.50

From ((5.A5), TB DY), TB DY: $\phi_c = 0.00340037$

c = confinement factor = 1.14004

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 937.50

fy₁ = 781.25

su₁ = 0.032

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

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

lo/lou,min = lb/d = 1.00

$su1 = 0.4 \cdot esu1_nominal ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 781.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.04544052$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.1239287$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.11291282$

and confined core properties:

$b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.05249828$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.14317713$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.13045028$

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

--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.1177224$
 $Mu = MRc (4.14) = 7.8532E+008$
 $u = su (4.1) = 7.1537995E-005$

Calculation of ratio lb/ld

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

Calculation of Mu2+

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

$$\phi_u = 1.5224730E-005$$

$$M_u = 1.0273E+009$$

with full section properties:

$$b = 250.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$\nu = 0.00207597$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu} = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00860501$$

$$\phi_{we} (5.4c) = 0.01628822$$

$$\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$$

$$\phi_{psh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$\phi_{psh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = fs = 781.25$$

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < sy1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made

```

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

--->

Subcase: Rupture of tension steel

--->

$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is satisfied

--->

*cu (4.10) = 0.46822902

M_{Ro} (4.17) = 1.0273E+009

--->

u = cu (4.2) = 1.5224730E-005

Mu = M_{Ro}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

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

u = 7.1537995E-005

Mu = 7.8532E+008

with full section properties:

b = 750.00

d = 507.00

d' = 43.00

v = 0.00069199

N = 9867.326

fc = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00860501

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

From (5.4b), TBDY: cu = 0.00860501

we (5.4c) = 0.01628822

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00
fywe = 781.25
fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004

y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032

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

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 781.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052

2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287

v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282

and confined core properties:

b = 690.00

$d = 477.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05249828$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.14317713$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.13045028$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.1177224$
 $Mu = MRc (4.14) = 7.8532E+008$
 $u = su (4.1) = 7.1537995E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 503762.797$

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 503762.797$
 $knl = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 $f_c' = 37.50$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $Mu = 788.0877$
 $Vu = 0.00014703$
 $d = 0.8*h = 440.00$
 $Nu = 9867.326$
 $Ag = 137500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$
 where:
 $V_{s1} = 287979.327$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 130899.694$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.75$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 447481.489$
 $bw = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 503762.797$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

fc' = 37.50, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 788.0877

Vu = 0.00014703

d = 0.8*h = 440.00

Nu = 9867.326

Ag = 137500.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 418879.02

where:

Vs1 = 287979.327 is calculated for section web, with:

d = 440.00

Av = 157079.633

fy = 625.00

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 130899.694 is calculated for section flange, with:

d = 200.00

Av = 157079.633

fy = 625.00

s = 150.00

Vs2 is multiplied by Col2 = 1.00

s/d = 0.75

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

From (11-11), ACI 440: Vs + Vf <= 447481.489

bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

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 = 37.50

New material of Primary Member: Steel Strength, fs = fsm = 625.00

Concrete Elasticity, Ec = 28781.504

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 = 781.25

#####

Max Height, Hmax = 550.00

Min Height, Hmin = 250.00

Max Width, Wmax = 750.00

Min Width, Wmin = 250.00

Eccentricity, Ecc = 250.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.14004

Element Length, L = 3000.00

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

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 3.6907929E-008$
EDGE -B-
Shear Force, $V_b = -3.6907929E-008$
BOTH EDGES
Axial Force, $F = -9867.326$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1231.504$
-Compression: $As_{l,com} = 1231.504$
-Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.36361$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.5430E+009$
 $\mu_{u1+} = 1.5430E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.5430E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.5430E+009$
 $\mu_{u2+} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 6.9461383E-005$
 $\mu_u = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $f_c = 37.50$
 $\phi_o (5A.5, TBDY) = 0.002$
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \max(\phi_{cu}, \phi_o) = 0.00860501$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_{cu} = 0.00860501$
 $\phi_{we} (5.4c) = 0.01628822$
 $\phi_{ase} = \max(\phi_{we}, \phi_{cu} * ((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$
The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

$psh,x \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$psh,y \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

$c = \text{confinement factor} = 1.14004$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 937.50$

$fy1 = 781.25$

$su1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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.

with $fs1 = fs = 781.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 937.50$

$fy2 = 781.25$

$su2 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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.

with $fs2 = fs = 781.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 937.50$

$fyv = 781.25$

$suv = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, 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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = A_{sl,ten}/(b * d) * (fs_1/fc) = 0.1451561$
 $2 = A_{sl,com}/(b * d) * (fs_2/fc) = 0.1451561$
 $v = A_{sl,mid}/(b * d) * (fsv/fc) = 0.31697352$

and confined core properties:

$b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b * d) * (fs_1/fc) = 0.19945845$
 $2 = A_{sl,com}/(b * d) * (fs_2/fc) = 0.19945845$
 $v = A_{sl,mid}/(b * d) * (fsv/fc) = 0.43555212$

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

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_1 -

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

$u = 6.9461383E-005$
 $Mu = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $fc = 37.50$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
 The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and
 is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length
 equal to half the clear spacing between hoops.
 $A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

$psh,x ((5.4d), TBDY) = L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$psh,y ((5.4d), TBDY) = L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5.A5), TBDY), TBDY: $cc = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 937.50$
 $fy1 = 781.25$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 \cdot esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, 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 $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 781.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 781.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.1451561$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.1451561$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.31697352$

and confined core properties:

$b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 42.75139$
 $cc \text{ (5A.5, TBDY)} = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.19945845$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19945845$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.43555212$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

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

--->

$su \text{ (4.8)} = 0.34839091$
 $Mu = MR_c \text{ (4.15)} = 1.5430E+009$
 $u = su \text{ (4.1)} = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

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

$u = 6.9461383E-005$
 $Mu = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $f_c = 37.50$
 $co \text{ (5A.5, TBDY)} = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00860501$

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

From (5.4b), TBDY: $cu = 0.00860501$

$w_e \text{ (5.4c)} = 0.01628822$

$ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) \cdot (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$$

$$psh,x ((5.4d), TBDY) = Lstir \cdot Astir / (Asec \cdot s) = 0.00271274$$

$$Lstir \text{ (Length of stirrups along Y)} = 1760.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$psh,y ((5.4d), TBDY) = Lstir \cdot Astir / (Asec \cdot s) = 0.00351061$$

$$Lstir \text{ (Length of stirrups along X)} = 1360.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$fywe = 781.25$$

$$fce = 37.50$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 937.50$$

$$fy1 = 781.25$$

$$su1 = 0.032$$

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

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

$$su1 = 0.4 \cdot esu1_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = fs = 781.25$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 937.50$$

$$fy2 = 781.25$$

$$su2 = 0.032$$

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

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

$$su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$$

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

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

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

$$\text{with } fs2 = fs = 781.25$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 937.50$$

$$fyv = 781.25$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = fs = 781.25$$

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

$$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.1451561$$

$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.1451561$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19945845$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19945845$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/d

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

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.9461383E-005$
 $Mu = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $f_c = 37.50$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
 The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.
 $A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$
 $p_{sh,x} (5.4d), TBDY = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 781.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561

2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561

v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352

and confined core properties:

b = 190.00

d = 677.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19945845$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19945845$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 754389.565$

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

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

$V_{Col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f_c^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 0.45248062$

$Vu = 3.6907929E-008$

$d = 0.8*h = 600.00$

$Nu = 9867.326$

$Ag = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$

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

VColO = 754389.565
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 37.50, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.45236986
Vu = 3.6907929E-008
d = 0.8*h = 600.00
Nu = 9867.326
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 523598.776
where:
Vs1 = 130899.694 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.75
Vs2 = 392699.082 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs2 is multiplied by Col2 = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 610202.031
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rctcs

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 = 37.50
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 28781.504
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -519569.932$
Shear Force, $V2 = -4487.046$
Shear Force, $V3 = 265.7264$
Axial Force, $F = -10860.955$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 2261.947$
-Compression: $A_{sc,com} = 829.3805$
-Middle: $A_{sc,mid} = 2060.885$
Mean Diameter of Tension Reinforcement, $D_{bL} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.01163902$
 $u = y + p = 0.01163902$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01041792$ ((4.29), Biskinis Phd))
 $M_y = 7.7156E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1955.282
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.8270E+013$
factor = 0.30
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10860.955$
 $E_c * I_g = 1.6090E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 1.0191412E-005$
with $f_y = 625.00$
 $d = 507.00$
 $y = 0.39520568$
 $A = 0.04078572$
 $B = 0.02735703$
with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10860.955$
 $b = 250.00$
 $" = 0.08481262$
 $y_{comp} = 1.1707932E-005$
with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.39509553$
 $A = 0.04046593$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

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

- Calculation of ρ -

From table 10-8: $\rho = 0.0012211$

with:

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

shear control ratio $V_yE/V_{ColOE} = 1.35949$

$d = 507.00$

$s = 0.00$

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

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1360.00$, is the total Length of all stirrups parallel to loading (shear) direction

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

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

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

$NUD = 10860.955$

$A_g = 262500.00$

$f_{cE} = 37.50$

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

$\rho_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.04064862$

$b = 250.00$

$d = 507.00$

$f_{cE} = 37.50$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

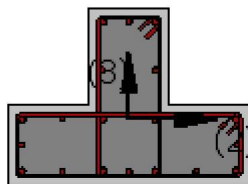
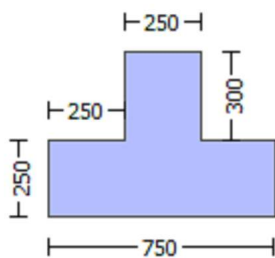
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_c = f_{cm} = 37.50$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -519569.932$

Shear Force, $V_a = 265.7264$

EDGE -B-

Bending Moment, $M_b = -277046.274$

Shear Force, $V_b = -265.7264$

BOTH EDGES

Axial Force, $F = -10860.955$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten} = 2261.947$
-Compression: $Asl_{com} = 829.3805$
-Middle: $Asl_{mid} = 2060.885$

Mean Diameter of Tension Reinforcement, $DbL_{ten} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 404687.169$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 404687.169$

$V_{CoI} = 404687.169$

$k_n = 1.00$

$displacement_ductility_demand = 0.00119871$

NOTE: In expression (10-3) ' V_s ' is replaced by ' $V_s + V_f$ '
where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)

$fc' = 25.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 519569.932$

$V_u = 265.7264$

$d = 0.8 \cdot h = 440.00$

$N_u = 10860.955$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 335103.216$

where:

$V_{s1} = 230383.461$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 104719.755$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.75$

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

From (11-11), ACI 440: $V_s + V_f \leq 365367.106$

$b_w = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 1.2488062E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.01041792$ ((4.29), Biskinis PhD)

$M_y = 7.7156E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1955.282

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 4.8270E+013$

$factor = 0.30$

$A_g = 262500.00$

$fc' = 37.50$

$N = 10860.955$

$E_c \cdot I_g = 1.6090E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.0191412\text{E-}005$
with $f_y = 625.00$
 $d = 507.00$
 $y = 0.39520568$
 $A = 0.04078572$
 $B = 0.02735703$
with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10860.955$
 $b = 250.00$
 $" = 0.08481262$
 $y_{\text{comp}} = 1.1707932\text{E-}005$
with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.39509553$
 $A = 0.04046593$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

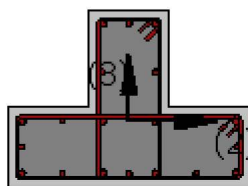
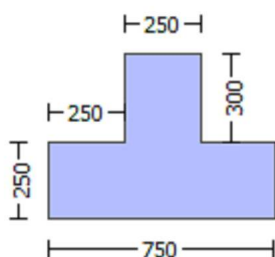
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 0.00014703$

EDGE -B-

Shear Force, $V_b = -0.00014703$

BOTH EDGES

Axial Force, $F = -9867.326$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 2261.947$

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

-Middle: $As_{l,mid} = 2060.885$

Calculation of Shear Capacity ratio , $V_e/V_r = 1.35949$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.0273\text{E}+009$

$\mu_{u1+} = 1.0273\text{E}+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u1-} = 7.8532\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.0273\text{E}+009$

$\mu_{u2+} = 1.0273\text{E}+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u2-} = 7.8532\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

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

$\mu_u = 1.5224730\text{E}-005$

$\mu_u = 1.0273\text{E}+009$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00207597$

$N = 9867.326$

$f_c = 37.50$

α_0 (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00860501$

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

From (5.4b), TBDY: $\mu_u = 0.00860501$

μ_{ue} (5.4c) = 0.01628822

$\mu_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00271274$

$\mu_{psh,x}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\mu_{psh,y}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5A.5), TBDY), TBDY: $cc = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 937.50$
 $fy1 = 781.25$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 781.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.37178611$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.13632157$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.33873846$
 and confined core properties:
 $b = 190.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.51995906$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.19065166$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.47374048$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 ---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 ---->
 Case/Assumption Rejected.
 ---->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 ---->
 $v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied
 ---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 ---->
 ϕ_{cu} (4.10) = 0.38433228
 M_{Rc} (4.17) = 9.9628E+008
 ---->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
 - $N, \phi_{cu1}, \phi_{cu2}$ normalised to b_o*d_o , instead of $b*d$
 - ϕ_{cc}, ϕ_{ccu} parameters of confined concrete, ϕ_{cc}, ϕ_{ccu} used in lieu of ϕ_{cc}, ϕ_{ccu}
 ---->
 Subcase: Rupture of tension steel
 ---->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 ---->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
 ---->
 Subcase rejected
 ---->
 New Subcase: Failure of compression zone
 ---->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is not satisfied
 ---->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is satisfied
 ---->
 ϕ^*_{cu} (4.10) = 0.46822902
 M_{Ro} (4.17) = 1.0273E+009
 ---->
 $u = \phi_{cu}$ (4.2) = 1.5224730E-005
 $M_u = M_{Ro}$

 Calculation of ratio I_b/I_d

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

Calculation of M_{u1} -

 Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 7.1537995E-005$
 $M_u = 7.8532E+008$

with full section properties:

$b = 750.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00069199$
 $N = 9867.326$
 $\phi_{cc} = 37.50$
 ϕ_{cc} (5A.5, TBDY) = 0.002
 Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00860501$

w_e (5.4c) = 0.01628822

$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

$p_{sh,x}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$p_{sh,y}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $c_c = 0.00340037$

c = confinement factor = 1.14004

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 937.50$

$fy_1 = 781.25$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 937.50$

$fy_2 = 781.25$

$su_2 = 0.032$

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

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

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282$

and confined core properties:

$b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028$

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

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

$su (4.9) = 0.1177224$
 $Mu = MRc (4.14) = 7.8532E+008$
 $u = su (4.1) = 7.1537995E-005$

Calculation of ratio lb/ld

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

Calculation of $Mu2+$

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

$u = 1.5224730E-005$
 $Mu = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$
 $fc = 37.50$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = Max(((Aconf,max - AnoConf)/Aconf,max)*(Aconf,min/Aconf,max), 0) = 0.28820848$
 The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization
 of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
 "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

$psh,x \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$psh,y \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

$c = \text{confinement factor} = 1.14004$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 937.50$

$fy_1 = 781.25$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 937.50$

$fy_2 = 781.25$

$su_2 = 0.032$

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

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

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$su_v = 0.032$

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

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

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

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

```

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY
For calculation of  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered
characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.
 $y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.
with  $f_{sv} = f_s = 781.25$ 
with  $E_{sv} = E_s = 200000.00$ 
1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.37178611$ 
2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.13632157$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.33873846$ 
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.51995906$ 
2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19065166$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.47374048$ 
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $\phi_{cu}$  (4.10) = 0.38433228
 $M_{Rc}$  (4.17) = 9.9628E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$ 
-  $N_1$ ,  $N_2$ ,  $v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$ 
- parameters of confined concrete, fcc, cc, used in lieu of  $f_c$ ,  $\phi_{cu}$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is not satisfied
---->
 $v^* < v^*_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $\phi_{cu}^*$  (4.10) = 0.46822902
 $M_{Ro}$  (4.17) = 1.0273E+009
---->
u =  $\phi_{cu}$  (4.2) = 1.5224730E-005
 $\mu_u = M_{Ro}$ 
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Calculation of ratio l_b/l_d

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

Calculation of μ_2 -

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

$$\mu = 7.1537995E-005$$

$$\mu_u = 7.8532E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00069199$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00860501$$

$$\mu_{ue} \text{ (5.4c)} = 0.01628822$$

$$\mu_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00271274$

$$\mu_{psh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$\mu_{psh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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

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

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

```

with fs1 = fs = 781.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224
Mu = MRc (4.14) = 7.8532E+008
u = su (4.1) = 7.1537995E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 503762.797

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$

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

$V_{Col0} = 503762.797$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 788.0877$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.75$

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

From (11-11), ACI 440: $V_s + V_f \leq 447481.489$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$

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

$V_{Col0} = 503762.797$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 788.0877$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

Vs2 is multiplied by Col2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 447481.489
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

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, $f_c = f_{cm} = 37.50$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 28781.504$
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, $f_s = 1.25 \cdot f_{sm} = 781.25$

Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 250.00$
Eccentricity, $E_{cc} = 250.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.14004
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 3.6907929E-008$
EDGE -B-
Shear Force, $V_b = -3.6907929E-008$
BOTH EDGES
Axial Force, $F = -9867.326$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1231.504$
-Compression: $As_{l,com} = 1231.504$
-Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio , $V_e/V_r = 1.36361$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$ with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.5430E+009$

$\mu_{1+} = 1.5430E+009$, 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

$\mu_{1-} = 1.5430E+009$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.5430E+009$

$\mu_{2+} = 1.5430E+009$, 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

$\mu_{2-} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

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

$\phi_u = 6.9461383E-005$

$M_u = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

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

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00860501$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00860501$

$\phi_{we} (5.4c) = 0.01628822$

$\phi_{ase} = \text{Max}((A_{conf,max} - A_{noConf})/A_{conf,max} * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$

$\phi_{psh,x} (5.4d, \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\phi_{psh,y} (5.4d, \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $\phi_{cc} = 0.00340037$

c = confinement factor = 1.14004

```

y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs1 = fs = 781.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 781.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->

```

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

--->

$$\mu_u(4.8) = 0.34839091$$

$$\mu_u = M_{Rc}(4.15) = 1.5430E+009$$

$$u = \mu_u(4.1) = 6.9461383E-005$$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u1} -

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

$$u = 6.9461383E-005$$

$$\mu_u = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00860501$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00860501$$

$$\mu_{ue}(5.4c) = 0.01628822$$

$$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00271274$

$$\mu_{sh,x}((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$\mu_{sh,y}((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.00340037$$

$$\alpha_c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 937.50$$

$$f_{y1} = 781.25$$

$$\mu_{u1} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
 For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 781.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 781.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 937.50$
 $fy_v = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/f_c) = 0.1451561$
 $2 = Asl_{com}/(b*d) * (fs_2/f_c) = 0.1451561$
 $v = Asl_{mid}/(b*d) * (fsv/f_c) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl_{ten}/(b*d) * (fs_1/f_c) = 0.19945845$
 $2 = Asl_{com}/(b*d) * (fs_2/f_c) = 0.19945845$
 $v = Asl_{mid}/(b*d) * (fsv/f_c) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$\mu = 6.9461383E-005$$

$$\mu_{2+} = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$\nu = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_{2+} = \text{shear_factor} * \text{Max}(\mu_{2+}, \omega) = 0.00860501$$

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

$$\text{From (5.4b), TB DY: } \mu_{2+} = 0.00860501$$

$$\omega (5.4c) = 0.01628822$$

$$\omega_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00271274$$

$$\mu_{sh,x} ((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$\mu_{sh,y} ((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TB DY), TB DY: } \omega_{cc} = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 937.50$$

$$f_{y1} = 781.25$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

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

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs1 = fs = 781.25$
with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs2 = fs = 781.25$
with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 781.25$
with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.1451561$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.1451561$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.31697352$
and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.19945845$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.19945845$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.43555212$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < vs, y2$ - LHS eq.(4.5) is not satisfied
--->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
--->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio lb/ld

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

Calculation of Mu2-

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

$$\mu = 6.9461383E-005$$

$$Mu = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } c_u: c_u = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00860501$$

$$w_e \text{ (5.4c)} = 0.01628822$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

$$p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

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

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

$$\text{with } fs_1 = fs = 781.25$$

```

with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 754389.565

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

$V_{r1} = V_{col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{col0}$

$V_{col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.45248062$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$

$V_{r2} = V_{col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{col0}$

$V_{col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.45236986$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

s = 150.00
Vs2 is multiplied by Col2 = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 610202.031
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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, $f_c = f_{cm} = 37.50$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 28781.504$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 250.00$
Eccentricity, $E_{cc} = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.3835E+007$
Shear Force, $V_2 = -4487.046$
Shear Force, $V_3 = 265.7264$
Axial Force, $F = -10860.955$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1231.504$
-Compression: $A_{st,com} = 1231.504$
-Middle: $A_{st,mid} = 2689.203$
Mean Diameter of Tension Reinforcement, $DbL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.01154252$
 $u = \gamma + \rho = 0.01154252$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01026021$ ((4.29), Biskinis Phd))
 $M_y = 7.9125E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3083.371
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.9262E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10860.955$
 $E_c * I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.3530147E-006$
with $f_y = 625.00$
 $d = 707.00$
 $y = 0.30425395$
 $A = 0.02924803$
 $B = 0.01555962$
with $p_t = 0.00696749$
 $p_c = 0.00696749$
 $p_v = 0.01521473$
 $N = 10860.955$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0916788E-005$
with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.30386172$
 $A = 0.02901871$
 $B = 0.01546131$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.00128231$

with:

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

shear control ratio $V_y E / V_{col} O E = 1.36361$

$d = 707.00$

$s = 0.00$

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

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1760.00$, is the total Length of all stirrups parallel to loading (shear) direction

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.

$N_{UD} = 10860.955$

$A_g = 262500.00$

$f_c E = 37.50$

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

$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.02914971$

$b = 250.00$

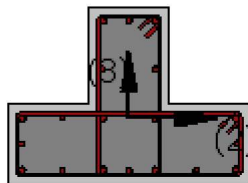
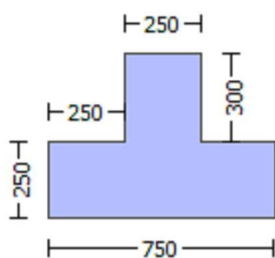
$d = 707.00$

$f_c E = 37.50$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5

column C1, Floor 1
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)
Analysis: Uniform +X
Check: Shear capacity V_{Rd}
Edge: End
Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 28781.504$
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, $f_c = f_{cm} = 37.50$
New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3835E+007
Shear Force, Va = -4487.046
EDGE -B-
Bending Moment, Mb = 370595.336
Shear Force, Vb = 4487.046
BOTH EDGES
Axial Force, F = -10860.955
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1231.504
-Compression: Asl,com = 1231.504
-Middle: Asl,mid = 2689.203
Mean Diameter of Tension Reinforcement, DbL,ten = 17.60

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = $1.0 \cdot V_n = 607874.181$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{ColO} = 607874.181$
 $V_{Col} = 607874.181$
 $knl = 1.00$
 $displacement_ductility_demand = 0.02754095$

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

= 1 (normal-weight concrete)
 $fc' = 25.00$, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 370595.336$
 $V_u = 4487.046$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 10860.955$
 $A_g = 187500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$
where:
 $V_{s1} = 104719.755$ is calculated for section web, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} is multiplied by Col1 = 1.00
 $s/d = 0.75$
 $V_{s2} = 314159.265$ is calculated for section flange, with:
 $d = 600.00$

$A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From $(11-11)$, ACI 440: $V_s + V_f \leq 498227.872$
 $bw = 250.00$

displacement ductility demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 2.7493531E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00099828 ((4.29), Biskinis Phd)$
 $M_y = 7.9125E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.9262E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10860.955$
 $E_c * I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.3530147E-006$
 with $f_y = 625.00$
 $d = 707.00$
 $y = 0.30425395$
 $A = 0.02924803$
 $B = 0.01555962$
 with $p_t = 0.00696749$
 $p_c = 0.00696749$
 $p_v = 0.01521473$
 $N = 10860.955$
 $b = 250.00$
 $\rho = 0.06082037$
 $y_{comp} = 1.0916788E-005$
 with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.30386172$
 $A = 0.02901871$
 $B = 0.01546131$
 with $E_s = 200000.00$

Calculation of ratio I_b / I_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 6

column C1, Floor 1

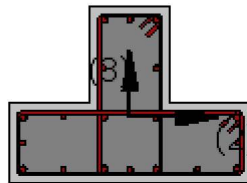
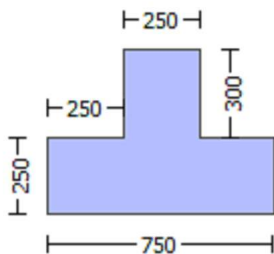
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 0.00014703$
EDGE -B-
Shear Force, $V_b = -0.00014703$
BOTH EDGES
Axial Force, $F = -9867.326$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 2261.947$
-Compression: $As_{l,com} = 829.3805$
-Middle: $As_{l,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.35949$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
with
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.0273E+009$
 $\mu_{1+} = 1.0273E+009$, 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
 $\mu_{1-} = 7.8532E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.0273E+009$
 $\mu_{2+} = 1.0273E+009$, 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
 $\mu_{2-} = 7.8532E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 1.5224730E-005$
 $\mu_u = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$
 $f_c = 37.50$
 $\alpha = 0.85$ (5A.5, TBDY) = 0.002
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha) = 0.00860501$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00860501$
 $\mu_{ue} = 0.01628822$
 $\alpha_{se} = \max((A_{conf,max} - A_{noConf})/A_{conf,max} * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and
 is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length
 equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

$psh,x ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$psh,y ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

$c = \text{confinement factor} = 1.14004$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 937.50$

$fy_1 = 781.25$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 937.50$

$fy_2 = 781.25$

$su_2 = 0.032$

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

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

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$su_v = 0.032$

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

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

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

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

considering characteristic value $fsy_v = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered

```

characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.
with  $f_{sv} = f_s = 781.25$ 
with  $E_{sv} = E_s = 200000.00$ 
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.37178611$ 
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.13632157$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.33873846$ 
and confined core properties:
 $b = 190.00$ 
 $d = 477.00$ 
 $d' = 13.00$ 
 $f_{cc} \text{ (5A.2, TBDY)} = 42.75139$ 
 $cc \text{ (5A.5, TBDY)} = 0.00340037$ 
 $c = \text{confinement factor} = 1.14004$ 
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.51995906$ 
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19065166$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.47374048$ 
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $c_u \text{ (4.10)} = 0.38433228$ 
 $M_{Rc} \text{ (4.17)} = 9.9628E+008$ 
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
-  $b, d, d'$  replaced by geometric parameters of the core:  $b_o, d_o, d'_o$ 
-  $N, 1, 2, v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$ 
-  $f_{cc}, cc$  parameters of confined concrete,  $f_{cc}, cc$ , used in lieu of  $f_c, e_{cu}$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is not satisfied
---->
 $v^* < v^*_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $*c_u \text{ (4.10)} = 0.46822902$ 
 $M_{Ro} \text{ (4.17)} = 1.0273E+009$ 
---->
 $u = c_u \text{ (4.2)} = 1.5224730E-005$ 
 $\mu = M_{Ro}$ 
-----

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

```

Calculation of Mu1-

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

$$\mu = 7.1537995E-005$$

$$Mu = 7.8532E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00069199$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu: \mu = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.00860501$$

$$w_e(5.4c) = 0.01628822$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

$$p_{sh,x}((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along } Y) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$p_{sh,y}((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along } X) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = fs = 781.25$$

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224
Mu = MRc (4.14) = 7.8532E+008
u = su (4.1) = 7.1537995E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

u = 1.5224730E-005
Mu = 1.0273E+009

with full section properties:

b = 250.00

d = 507.00

d' = 43.00

v = 0.00207597

N = 9867.326

fc = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00860501

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

From (5.4b), TBDY: cu = 0.00860501

we (5.4c) = 0.01628822

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max by a length

equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*,y2 - LHS eq.(4.5) is not satisfied

```



```

---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
---->
*cu (4.10) = 0.46822902
MRo (4.17) = 1.0273E+009
---->
u = cu (4.2) = 1.5224730E-005
Mu = MRo

```

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu₂-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 7.1537995E-005
Mu = 7.8532E+008

with full section properties:

```

b = 750.00
d = 507.00
d' = 43.00
v = 0.00069199
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

```

```

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

```

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

```

s = 150.00
fywe = 781.25
fce = 37.50
From ((5A.5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004
y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 781.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13045028$$

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

--->

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

--->

$$s_u (4.9) = 0.1177224$$

$$M_u = M_{Rc} (4.14) = 7.8532E+008$$

$$u = s_u (4.1) = 7.1537995E-005$$

Calculation of ratio l_b / l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 503762.797$

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$

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

$$V_{Col0} = 503762.797$$

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

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

= 1 (normal-weight concrete)

$$f_c' = 37.50, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M / Vd = 4.00$$

$$M_u = 788.0877$$

$$V_u = 0.00014703$$

$$d = 0.8 \cdot h = 440.00$$

$$N_u = 9867.326$$

$$A_g = 137500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 418879.02$$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$$d = 440.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.34090909$$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

V_{s2} is multiplied by $Col2 = 1.00$

$$s/d = 0.75$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 447481.489$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$

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

$$V_{Col0} = 503762.797$$

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

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

= 1 (normal-weight concrete)

$$f_c' = 37.50, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$M/Vd = 4.00$
 $Mu = 788.0877$
 $Vu = 0.00014703$
 $d = 0.8 \cdot h = 440.00$
 $Nu = 9867.326$
 $Ag = 137500.00$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 = 418879.02$
 where:
 $Vs1 = 287979.327$ is calculated for section web, with:
 $d = 440.00$
 $Av = 157079.633$
 $fy = 625.00$
 $s = 150.00$
 $Vs1$ is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $Vs2 = 130899.694$ is calculated for section flange, with:
 $d = 200.00$
 $Av = 157079.633$
 $fy = 625.00$
 $s = 150.00$
 $Vs2$ is multiplied by $Col2 = 1.00$
 $s/d = 0.75$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 447481.489$
 $bw = 250.00$

 End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rctcs

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, $fc = fcm = 37.50$
 New material of Primary Member: Steel Strength, $fs = fsm = 625.00$
 Concrete Elasticity, $Ec = 28781.504$
 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, $fs = 1.25 \cdot fsm = 781.25$
 #####
 Max Height, $Hmax = 550.00$
 Min Height, $Hmin = 250.00$
 Max Width, $Wmax = 750.00$
 Min Width, $Wmin = 250.00$
 Eccentricity, $Ecc = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.14004
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($lo/ou, min \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6907929E-008$

EDGE -B-

Shear Force, $V_b = -3.6907929E-008$

BOTH EDGES

Axial Force, $F = -9867.326$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1231.504$

-Compression: $As_{l,com} = 1231.504$

-Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.36361$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.5430E+009$

$Mu_{1+} = 1.5430E+009$, 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

$Mu_{1-} = 1.5430E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.5430E+009$

$Mu_{2+} = 1.5430E+009$, 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

$Mu_{2-} = 1.5430E+009$, 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:

$\phi_u = 6.9461383E-005$

$Mu = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00860501$

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

From (5.4b), TBDY: $\phi_u = 0.00860501$

ϕ_{we} (5.4c) = 0.01628822

$\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} = \text{Min}(psh_x, psh_y) = 0.00271274$

$psh_x ((5.4d), TBDY) = L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$psh_y ((5.4d), TBDY) = L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$
 c = confinement factor = 1.14004

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 937.50$
 $fy_1 = 781.25$
 $su_1 = 0.032$

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

$lo/lo_{min} = lb/l_d = 1.00$

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$

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

$lo/lo_{min} = lb/l_b, min = 1.00$

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 937.50$
 $fy_v = 781.25$
 $suv = 0.032$

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

$lo/lo_{min} = lb/l_d = 1.00$

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

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

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

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

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

```

with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

u = 6.9461383E-005
Mu = 1.5430E+009

with full section properties:

```

b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

```

$$psh,x ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00271274$$

$$Lstir \text{ (Length of stirrups along Y)} = 1760.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$psh,y ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00351061$$

$$Lstir \text{ (Length of stirrups along X)} = 1360.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$fywe = 781.25$$

$$fce = 37.50$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 937.50$$

$$fy1 = 781.25$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 781.25$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 937.50$$

$$fy2 = 781.25$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 781.25$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 937.50$$

$$fyv = 781.25$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = fs = 781.25$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.1451561$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.1451561$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.31697352$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 42.75139$$

$$cc(5A.5, TBDY) = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19945845$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19945845$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.43555212$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

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

--->

$$s_u(4.8) = 0.34839091$$

$$\mu_u = M_{Rc}(4.15) = 1.5430E+009$$

$$u = s_u(4.1) = 6.9461383E-005$$

Calculation of ratio l_b/d

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

Calculation of μ_{u2+}

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

$$u = 6.9461383E-005$$

$$\mu_u = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00860501$$

$$\mu_{ue}(5.4c) = 0.01628822$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

$$p_{sh,x}(5.4d, TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

psh,y ((5.4d), TBDY) = $L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00351061$

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = $0.4 \cdot esu1_nominal$ ((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 = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

su2 = $0.4 \cdot esu2_nominal$ ((5.5), TBDY) = 0.032

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

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

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

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

with fsv = fs = 781.25

with Esv = Es = 200000.00

1 = $Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.1451561$

2 = $Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.1451561$

v = $Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.31697352$

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 42.75139

```

cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

```

u = 6.9461383E-005
Mu = 1.5430E+009

```

with full section properties:

```

b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

```

```

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

```

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 937.50$
 $fy1 = 781.25$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 781.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.1451561$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.1451561$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.19945845$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.19945845$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.43555212$

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

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

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

--->

s_u (4.8) = 0.34839091

$\mu_u = M_{Rc}$ (4.15) = 1.5430E+009

$u = s_u$ (4.1) = 6.9461383E-005

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 754389.565$

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

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

$V_{Col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.45248062$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$

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

$V_{Col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.45236986$
 $V_u = 3.6907929E-008$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 9867.326$
 $A_g = 187500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$
 where:
 $V_{s1} = 130899.694$ is calculated for section web, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.75$
 $V_{s2} = 392699.082$ is calculated for section flange, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 610202.031$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
 At local axis: 2

 Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
 At local axis: 2
 Integration Section: (b)
 Section Type: rctcs

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 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, $f_c = f_{cm} = 37.50$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 28781.504$
 Steel Elasticity, $E_s = 200000.00$
 Max Height, $H_{max} = 550.00$
 Min Height, $H_{min} = 250.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 250.00$
 Eccentricity, $E_{cc} = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d > 1$)
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = -277046.274$
 Shear Force, $V2 = 4487.046$
 Shear Force, $V3 = -265.7264$
 Axial Force, $F = -10860.955$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{ten} = 2261.947$
 -Compression: $As_{com} = 829.3805$
 -Middle: $As_{mid} = 2060.885$
 Mean Diameter of Tension Reinforcement, $Db_L = 17.77778$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00677617$
 $u = y + p = 0.00677617$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00555507$ ((4.29), Biskinis Phd))
 $M_y = 7.7156E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1042.60
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.8270E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10860.955$
 $E_c * I_g = 1.6090E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0191412E-005$
 with $f_y = 625.00$
 $d = 507.00$
 $y = 0.39520568$
 $A = 0.04078572$
 $B = 0.02735703$
 with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10860.955$
 $b = 250.00$
 $" = 0.08481262$
 $y_{comp} = 1.1707932E-005$
 with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.39509553$
 $A = 0.04046593$
 $B = 0.02721993$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.0012211$

with:

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

shear control ratio $V_{yE}/V_{ColOE} = 1.35949$

$d = 507.00$

$s = 0.00$

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

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1360.00$, is the total Length of all stirrups parallel to loading (shear) direction

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

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

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

$N_{UD} = 10860.955$

$A_g = 262500.00$

$f_{cE} = 37.50$

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

$p_l = \text{Area_Tot_Long_Rein}/(b \cdot d) = 0.04064862$

$b = 250.00$

$d = 507.00$

$f_{cE} = 37.50$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

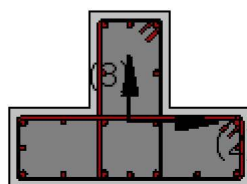
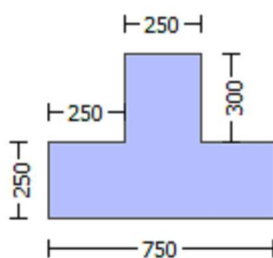
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3
Integration Section: (b)
Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_c = f_{cm} = 37.50$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -519569.932$

Shear Force, $V_a = 265.7264$

EDGE -B-

Bending Moment, $M_b = -277046.274$

Shear Force, $V_b = -265.7264$

BOTH EDGES

Axial Force, $F = -10860.955$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression: $A_{sl,c} = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 2261.947$

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

-Middle: $A_{sl,mid} = 2060.885$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 452567.023$

V_n ((10-3), ASCE 41-17) = $k_n l \cdot V_{CoI} = 452567.023$

$V_{CoI} = 452567.023$

$k_n l = 1.00$

$displacement_ductility_demand = 2.7374639E-006$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ $f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

$\lambda = 1$ (normal-weight concrete)
 $f'_c = 25.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.36955$
 $\mu_u = 277046.274$
 $V_u = 265.7264$
 $d = 0.8 \cdot h = 440.00$
 $N_u = 10860.955$
 $A_g = 137500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 335103.216$
 where:
 $V_{s1} = 230383.461$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 104719.755$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $\text{Col2} = 1.00$
 $s/d = 0.75$
 $V_f ((11-3)-(11.4), \text{ACI 440}) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 365367.106$
 $b_w = 250.00$

displacement ductility demand is calculated as δ_u / y

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

From analysis, chord rotation $\theta_r = 1.5206802\text{E-}008$
 $y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00555507$ ((4.29), Biskinis Phd))
 $M_y = 7.7156\text{E+}008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1042.60
 From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 4.8270\text{E+}013$
 $\text{factor} = 0.30$
 $A_g = 262500.00$
 $f'_c = 37.50$
 $N = 10860.955$
 $E_c \cdot I_g = 1.6090\text{E+}014$

Calculation of Yielding Moment M_y

Calculation of δ_u and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 1.0191412\text{E-}005$
 with $f_y = 625.00$
 $d = 507.00$
 $y = 0.39520568$
 $A = 0.04078572$
 $B = 0.02735703$
 with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10860.955$
 $b = 250.00$
 $\lambda = 0.08481262$
 $y_{\text{comp}} = 1.1707932\text{E-}005$

with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.39509553$
 $A = 0.04046593$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

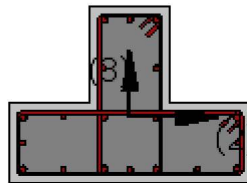
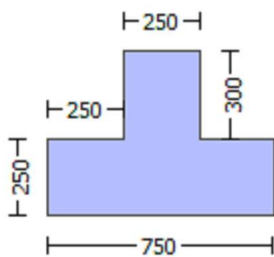
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$
 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, $f_s = 1.25 \cdot f_{sm} = 781.25$
 #####
 Max Height, $H_{max} = 550.00$
 Min Height, $H_{min} = 250.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 250.00$
 Eccentricity, $Ecc = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.14004
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} > 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 0.00014703$
 EDGE -B-
 Shear Force, $V_b = -0.00014703$
 BOTH EDGES
 Axial Force, $F = -9867.326$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 2261.947$
 -Compression: $A_{st,com} = 829.3805$
 -Middle: $A_{st,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.35949$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.0273E+009$
 $\mu_{u1+} = 1.0273E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 7.8532E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.0273E+009$
 $\mu_{u2+} = 1.0273E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $\mu_{u2-} = 7.8532E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.5224730E-005$
 $\mu_u = 1.0273E+009$

with full section properties:

$$b = 250.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00207597$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \alpha) = 0.00860501$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00860501$$

$$\phi_e (5.4c) = 0.01628822$$

$$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00271274$$

$$\phi_{sh,x} ((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$\phi_{sh,y} ((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.00340037$$

$$\alpha_c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 937.50$$

$$f_{y1} = 781.25$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

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

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

For calculation of $esu_{1,nominal}$ and y_1 , sh_1 , f_{t1} , f_{y1} , it is considered

characteristic value $fs_{y1} = f_s / 1.2$, from table 5.1, TB DY.

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

$$\text{with } fs_1 = f_s = 781.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$f_{t2} = 937.50$$

$$f_{y2} = 781.25$$

$$su_2 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

```

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied

```

```

--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
 $v^* < v^*c,y2$  - LHS eq.(4.6) is not satisfied
--->
 $v^* < v^*c,y1$  - RHS eq.(4.6) is satisfied
--->
 $*cu(4.10) = 0.46822902$ 
 $MRO(4.17) = 1.0273E+009$ 
--->
 $u = cu(4.2) = 1.5224730E-005$ 
 $Mu = MRO$ 

```

Calculation of ratio lb/ld

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

Calculation of $Mu1$ -

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

$u = 7.1537995E-005$

$Mu = 7.8532E+008$

with full section properties:

$b = 750.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00069199$

$N = 9867.326$

$fc = 37.50$

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

Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00860501$

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

From (5.4b), TBDY: $cu = 0.00860501$

$we(5.4c) = 0.01628822$

$ase = Max(((Aconf,max - AnoConf)/Aconf,max) * (Aconf,min/Aconf,max), 0) = 0.28820848$

The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$Aconf,max = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$Aconf,min = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $Aconf,max$ by a length equal to half the clear spacing between hoops.

$AnoConf = 95733.333$ is the unconfined core area which is equal to $bi^2/6$ as defined at (A.2).

$psh,min = Min(psh,x, psh,y) = 0.00271274$

$psh,x(5.4d, TBDY) = Lstir * Astir / (Asec * s) = 0.00271274$

$Lstir$ (Length of stirrups along Y) = 1760.00

$Astir$ (stirrups area) = 78.53982

$Asec$ (section area) = 262500.00

$psh,y(5.4d, TBDY) = Lstir * Astir / (Asec * s) = 0.00351061$

$Lstir$ (Length of stirrups along X) = 1360.00

$Astir$ (stirrups area) = 78.53982

$Asec$ (section area) = 262500.00

$s = 150.00$

```

fywe = 781.25
fce = 37.50
From ((5A.5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004
y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 781.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfinedsd full section - Steel rupture

```


satisfies Eq. (4.3)

--->

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

--->

$\mu_u(4.9) = 0.1177224$

$\mu_u = M_{Rc}(4.14) = 7.8532E+008$

$u = \mu_u(4.1) = 7.1537995E-005$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u2+}

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

$\mu_u = 1.5224730E-005$

$\mu_u = 1.0273E+009$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00207597$

$N = 9867.326$

$f_c = 37.50$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00860501$

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

From (5.4b), TB DY: $\mu_u = 0.00860501$

$\mu_{ue}(5.4c) = 0.01628822$

$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00271274$

$\mu_{psh,x}(5.4d, \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\mu_{psh,y}(5.4d, \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TB DY), TB DY: $\mu_c = 0.00340037$

$\mu_c = \text{confinement factor} = 1.14004$

$\mu_{y1} = 0.0025$

$\mu_{sh1} = 0.008$

$f_{t1} = 937.50$

```

fy1 = 781.25
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs1 = fs = 781.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 781.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.

```

```

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
---->
*cu (4.10) = 0.46822902
MRo (4.17) = 1.0273E+009
---->
u = cu (4.2) = 1.5224730E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----
Calculation of Mu2-
-----
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 7.1537995E-005
Mu = 7.8532E+008
-----

with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00069199
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).

```

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length
equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

 $psh,x \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $psh,y \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

$c = \text{confinement factor} = 1.14004$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 937.50$

$fy1 = 781.25$

$su1 = 0.032$

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

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

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

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.

with $fs1 = fs = 781.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 937.50$

$fy2 = 781.25$

$su2 = 0.032$

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

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

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

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.

with $fs2 = fs = 781.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 937.50$

$fyv = 781.25$

$suv = 0.032$

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

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

$\text{su} = 0.4 \cdot \text{esuv_nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $\text{esuv_nominal} = 0.08$,
 considering characteristic value $\text{fsy} = \text{fsv}/1.2$, from table 5.1, TBDY
 For calculation of esuv_nominal and yv , shv , ftv , fyv , it is considered
 characteristic value $\text{fsy} = \text{fsv}/1.2$, from table 5.1, TBDY.
 y1 , sh1 , ft1 , fy1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.
 with $\text{fsv} = \text{fs} = 781.25$
 with $\text{Esv} = \text{Es} = 200000.00$
 $1 = \text{Asl,ten}/(\text{b} \cdot \text{d}) \cdot (\text{fs1}/\text{fc}) = 0.04544052$
 $2 = \text{Asl,com}/(\text{b} \cdot \text{d}) \cdot (\text{fs2}/\text{fc}) = 0.1239287$
 $v = \text{Asl,mid}/(\text{b} \cdot \text{d}) \cdot (\text{fsv}/\text{fc}) = 0.11291282$
 and confined core properties:
 $\text{b} = 690.00$
 $\text{d} = 477.00$
 $\text{d}' = 13.00$
 $\text{fcc} (5A.2, \text{TBDY}) = 42.75139$
 $\text{cc} (5A.5, \text{TBDY}) = 0.00340037$
 $\text{c} = \text{confinement factor} = 1.14004$
 $1 = \text{Asl,ten}/(\text{b} \cdot \text{d}) \cdot (\text{fs1}/\text{fc}) = 0.05249828$
 $2 = \text{Asl,com}/(\text{b} \cdot \text{d}) \cdot (\text{fs2}/\text{fc}) = 0.14317713$
 $v = \text{Asl,mid}/(\text{b} \cdot \text{d}) \cdot (\text{fsv}/\text{fc}) = 0.13045028$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < \text{vs,y2}$ - LHS eq.(4.5) is satisfied
 ---->
 $\text{su} (4.9) = 0.1177224$
 $\text{Mu} = \text{MRc} (4.14) = 7.8532\text{E}+008$
 $u = \text{su} (4.1) = 7.1537995\text{E}-005$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $\text{Vr} = \text{Min}(\text{Vr1}, \text{Vr2}) = 503762.797$

Calculation of Shear Strength at edge 1, $\text{Vr1} = 503762.797$

$\text{Vr1} = \text{VCol} ((10.3), \text{ASCE 41-17}) = \text{knl} \cdot \text{VColO}$

$\text{VColO} = 503762.797$

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

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

$= 1$ (normal-weight concrete)

$\text{fc}' = 37.50$, but $\text{fc}^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$\text{M}/\text{Vd} = 4.00$

$\text{Mu} = 788.0877$

$\text{Vu} = 0.00014703$

$\text{d} = 0.8 \cdot \text{h} = 440.00$

$\text{Nu} = 9867.326$

$\text{Ag} = 137500.00$

From (11.5.4.8), ACI 318-14: $\text{Vs} = \text{Vs1} + \text{Vs2} = 418879.02$

where:

$\text{Vs1} = 287979.327$ is calculated for section web, with:

$\text{d} = 440.00$

$\text{Av} = 157079.633$

$\text{fy} = 625.00$

$\text{s} = 150.00$

Vs1 is multiplied by $\text{Col1} = 1.00$

$\text{s}/\text{d} = 0.34090909$

$\text{Vs2} = 130899.694$ is calculated for section flange, with:

$\text{d} = 200.00$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.75$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 447481.489$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$

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

$$V_{Col0} = 503762.797$$

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

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

= 1 (normal-weight concrete)

$$f'_c = 37.50, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 4.00$$

$$\mu_u = 788.0877$$

$$V_u = 0.00014703$$

$$d = 0.8 * h = 440.00$$

$$N_u = 9867.326$$

$$A_g = 137500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 418879.02$$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$$d = 440.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.34090909$$

Vs2 = 130899.694 is calculated for section flange, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.75$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 447481.489$$

$$b_w = 250.00$$

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6907929E-008$

EDGE -B-

Shear Force, $V_b = -3.6907929E-008$

BOTH EDGES

Axial Force, $F = -9867.326$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1231.504$

-Compression: $As_{c,com} = 1231.504$

-Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio , $V_e/V_r = 1.36361$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.5430E+009$

$\mu_{u1+} = 1.5430E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination

$\mu_{u1-} = 1.5430E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.5430E+009$

$\mu_{u2+} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination

$\mu_{u2-} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of μ_{u1+}

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

$\phi_u = 6.9461383E-005$

$M_u = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $f_c = 37.50$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = Max(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$
 The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.
 $A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i d_i / 6$ as defined at (A.2).
 $psh,min = Min(psh,x, psh,y) = 0.00271274$

$psh,x ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$psh,y ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5.A5), TBDY), TBDY: $cc = 0.00340037$
 $c =$ confinement factor = 1.14004
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 937.50$
 $fy1 = 781.25$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $lo/lou,min = lb/d = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2 , sh_2 , ft_2 , fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$suv = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$suv = 0.4 \cdot es_{u_nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: $es_{u_nominal} = 0.08$,

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

For calculation of $es_{u_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered

characteristic value $fs_{yv} = f_{sv}/1.2$, 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 $f_{sv} = fs = 781.25$

with $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.1451561$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.1451561$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.31697352$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, \text{TBDY}) = 42.75139$

$cc (5A.5, \text{TBDY}) = 0.00340037$

$c = \text{confinement factor} = 1.14004$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.19945845$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19945845$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.43555212$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

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

--->

$su (4.8) = 0.34839091$

$Mu = MR_c (4.15) = 1.5430E+009$

$u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_1 -

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

$u = 6.9461383E-005$

$Mu = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha_c = 0.00860501$
 $w_e (5.4c) = 0.01628822$
 $\alpha_{se} = \text{Max}(((\alpha_{conf,max} - \alpha_{noconf}) / \alpha_{conf,max}) * (\alpha_{conf,min} / \alpha_{conf,max}), 0) = 0.28820848$
 The definitions of α_{noconf} , $\alpha_{conf,min}$ and $\alpha_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $\alpha_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $\alpha_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $\alpha_{conf,max}$ by a length equal to half the clear spacing between hoops.
 $\alpha_{noconf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\alpha_{sh,min} = \text{Min}(\alpha_{sh,x}, \alpha_{sh,y}) = 0.00271274$

$\alpha_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$\alpha_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5A5), TBDY), TBDY: $\alpha_c = 0.00340037$
 α_c = confinement factor = 1.14004
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 937.50$
 $fy_1 = 781.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * \alpha_{su1_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\alpha_{su1_nominal} = 0.08$,
 For calculation of $\alpha_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 781.25$
 with $E_{s1} = E_s = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * \alpha_{su2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\alpha_{su2_nominal} = 0.08$,
 For calculation of $\alpha_{su2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 781.25$
 with $E_{s2} = E_s = 200000.00$

```

yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
    2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
    v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

```

u = 6.9461383E-005
Mu = 1.5430E+009

```

with full section properties:

```

b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
    N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
    The Shear_factor is considered equal to 1 (pure moment strength)
    From (5.4b), TBDY: cu = 0.00860501

```

$$w_e (5.4c) = 0.01628822$$

$$ase = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

$$p_{sh,x} ((5.4d), \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$p_{sh,y} ((5.4d), \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From } ((5.A5), \text{TBDY}), \text{TBDY: } cc = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

$$\text{Shear_factor} = 1.00$$

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

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

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

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

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

$$\text{with } fs_1 = fs = 781.25$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 937.50$$

$$fy_2 = 781.25$$

$$su_2 = 0.032$$

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

$$\text{Shear_factor} = 1.00$$

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

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

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

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

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

$$\text{with } fs_2 = fs = 781.25$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 937.50$$

$$fy_v = 781.25$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 781.25$
with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.1451561$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.1451561$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.31697352$
and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.19945845$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.19945845$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.43555212$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
--->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_2 -

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

$u = 6.9461383E-005$
 $Mu = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $fc = 37.50$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

$p_{sh,x} ((5.4d), \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$p_{sh,y} ((5.4d), \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

c = confinement factor = 1.14004

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 937.50$

$fy_1 = 781.25$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 937.50$

$fy_2 = 781.25$

$su_2 = 0.032$

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$suv = 0.032$

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

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

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

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv_nominal}$ and y_v , sh_v , ft_v , f_{yv} , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1 , sh_1 , ft_1 , f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 781.25$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.1451561$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.1451561$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 42.75139$
 $cc \text{ (5A.5, TBDY)} = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.19945845$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19945845$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.8)} = 0.34839091$
 $Mu = MR_c \text{ (4.15)} = 1.5430E+009$
 $u = su \text{ (4.1)} = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 754389.565$

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

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

$V_{ColO} = 754389.565$

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

NOTE: In expression (10-3) ' V_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)

$f_c' = 37.50$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 0.45248062$

$Vu = 3.6907929E-008$

$d = 0.8 \cdot h = 600.00$

$Nu = 9867.326$

$Ag = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

d = 600.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs2 is multiplied by Col2 = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 610202.031
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 754389.565
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 754389.565
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
fc' = 37.50, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.45236986
Vu = 3.6907929E-008
d = 0.8*h = 600.00
Nu = 9867.326
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 523598.776
where:
Vs1 = 130899.694 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.75
Vs2 = 392699.082 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs2 is multiplied by Col2 = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 610202.031
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

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 = 37.50
New material of Primary Member: Steel Strength, fs = fsm = 625.00

Concrete Elasticity, $E_c = 28781.504$
 Steel Elasticity, $E_s = 200000.00$
 Max Height, $H_{max} = 550.00$
 Min Height, $H_{min} = 250.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 250.00$
 Eccentricity, $Ecc = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 370595.336$
 Shear Force, $V_2 = 4487.046$
 Shear Force, $V_3 = -265.7264$
 Axial Force, $F = -10860.955$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1231.504$
 -Compression: $A_{st,com} = 1231.504$
 -Middle: $A_{st,mid} = 2689.203$
 Mean Diameter of Tension Reinforcement, $D_bL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00228059$
 $u = y + p = 0.00228059$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00099828$ ((4.29), Biskinis Phd))
 $M_y = 7.9125E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.9262E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10860.955$
 $E_c * I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.3530147E-006$
 with $f_y = 625.00$
 $d = 707.00$
 $y = 0.30425395$
 $A = 0.02924803$
 $B = 0.01555962$
 with $p_t = 0.00696749$
 $p_c = 0.00696749$

$$p_v = 0.01521473$$

$$N = 10860.955$$

$$b = 250.00$$

$$s = 0.06082037$$

$$y_{comp} = 1.0916788E-005$$

$$\text{with } f_c = 37.50$$

$$E_c = 28781.504$$

$$y = 0.30386172$$

$$A = 0.02901871$$

$$B = 0.01546131$$

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

Calculation of ratio l_b/l_d

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

- Calculation of p -

From table 10-8: $p = 0.00128231$

with:

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

$$\text{shear control ratio } V_y E / V_{Col} E = 1.36361$$

$$d = 707.00$$

$$s = 0.00$$

$$t = A_v / (b w s) + 2 t_f / b w (f_{fe} / f_s) = A_v L_{stir} / (A_g s) + 2 t_f / b w (f_{fe} / f_s) = 0.00$$

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1760.00$, is the total Length of all stirrups parallel to loading (shear) direction

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.

$$N_{UD} = 10860.955$$

$$A_g = 262500.00$$

$$f_{cE} = 37.50$$

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

$$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.02914971$$

$$b = 250.00$$

$$d = 707.00$$

$$f_{cE} = 37.50$$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

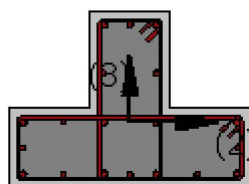
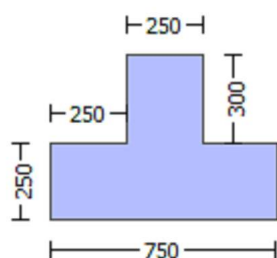
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_c = f_{cm} = 37.50$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -8.7997\text{E}+006$
 Shear Force, $V_a = -2853.907$
 EDGE -B-
 Bending Moment, $M_b = 235710.829$
 Shear Force, $V_b = 2853.907$
 BOTH EDGES
 Axial Force, $F = -10499.307$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1231.504$
 -Compression: $A_{sc,com} = 1231.504$
 -Middle: $A_{st,mid} = 2689.203$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 17.60$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 513340.842$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col0} = 513340.842$
 $V_{Col} = 513340.842$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.00469494$

NOTE: In expression (10-3) ' V_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)
 $f'_c = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 4.00$
 $M_u = 8.7997\text{E}+006$
 $V_u = 2853.907$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 10499.307$
 $A_g = 187500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$
 where:
 $V_{s1} = 104719.755$ is calculated for section web, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.75$
 $V_{s2} = 314159.265$ is calculated for section flange, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 498227.872$
 $bw = 250.00$

$displacement_ductility_demand$ is calculated as ϕ / y

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

From analysis, chord rotation $\phi = 4.8165359\text{E}-005$
 $y = (M_y \cdot L_s / 3) / Eleff = 0.01025899$ ((4.29), Biskinis Phd))

$M_y = 7.9116E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3083.371
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 7.9262E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10499.307$
 $E_c \cdot I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.3527299E-006$
with $f_y = 625.00$
 $d = 707.00$
 $y = 0.30422276$
 $A = 0.02924476$
 $B = 0.01555635$
with $pt = 0.00696749$
 $pc = 0.00696749$
 $pv = 0.01521473$
 $N = 10499.307$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0917443E-005$
with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.3038435$
 $A = 0.02902307$
 $B = 0.01546131$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 10

column C1, Floor 1

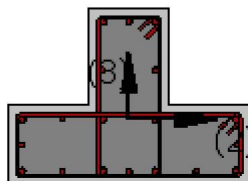
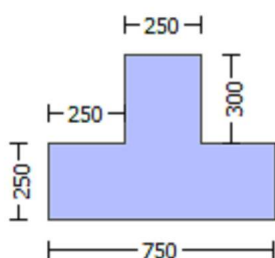
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-
 Shear Force, $V_a = 0.00014703$
 EDGE -B-
 Shear Force, $V_b = -0.00014703$
 BOTH EDGES
 Axial Force, $F = -9867.326$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 2261.947$
 -Compression: $A_{sc,com} = 829.3805$
 -Middle: $A_{sc,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.35949$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
 with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.0273E+009$
 $M_{u1+} = 1.0273E+009$, 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
 $M_{u1-} = 7.8532E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.0273E+009$
 $M_{u2+} = 1.0273E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the static loading combination
 $M_{u2-} = 7.8532E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.5224730E-005$
 $M_u = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$

$f_c = 37.50$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00860501$

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

From (5.4b), TBDY: $\phi_u = 0.00860501$

we (5.4c) $\phi_u = 0.01628822$

$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

$$psh,x ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00271274$$

$$Lstir \text{ (Length of stirrups along Y)} = 1760.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$psh,y ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00351061$$

$$Lstir \text{ (Length of stirrups along X)} = 1360.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$fywe = 781.25$$

$$fce = 37.50$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 937.50$$

$$fy1 = 781.25$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 781.25$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 937.50$$

$$fy2 = 781.25$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 781.25$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 937.50$$

$$fyv = 781.25$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = fs = 781.25$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.37178611$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.13632157$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.33873846$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 42.75139$$

$$cc(5A.5, TBDY) = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.51995906$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19065166$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.47374048$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

--->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

--->

$$cu(4.10) = 0.38433228$$

$$MRc(4.17) = 9.9628E+008$$

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o , d_o , d'_o
- N_1 , N_2 , v normalised to b_o*d_o , instead of $b*d$
- parameters of confined concrete, f_{cc} , cc , used in lieu of f_c , ecu

--->

Subcase: Rupture of tension steel

--->

$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is satisfied

--->

$$*cu(4.10) = 0.46822902$$

$$MRo(4.17) = 1.0273E+009$$

--->

$$u = cu(4.2) = 1.5224730E-005$$

$$Mu = MRo$$

Calculation of ratio l_b/d

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

Calculation of $Mu1$ -

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

u = 7.1537995E-005
Mu = 7.8532E+008

with full section properties:

b = 750.00

d = 507.00

d' = 43.00

v = 0.00069199

N = 9867.326

fc = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$

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

From (5.4b), TBDY: $cu = 0.00860501$

we (5.4c) = 0.01628822

$ase = \text{Max}(((A_{\text{conf,max}} - A_{\text{noConf}}) / A_{\text{conf,max}}) * (A_{\text{conf,min}} / A_{\text{conf,max}}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{\text{conf,min}}$ and $A_{\text{conf,max}}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max}} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{\text{conf,min}} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{\text{conf,max}}$ by a length

equal to half the clear spacing between hoops.

$A_{\text{noConf}} = 95733.333$ is the unconfined core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$psh_{\text{min}} = \text{Min}(psh_x, psh_y) = 0.00271274$

$psh_x \text{ ((5.4d), TBDY)} = L_{\text{stir}} * A_{\text{stir}} / (A_{\text{sec}} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$psh_y \text{ ((5.4d), TBDY)} = L_{\text{stir}} * A_{\text{stir}} / (A_{\text{sec}} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

s = 150.00

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

c = confinement factor = 1.14004

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 937.50$

$fy1 = 781.25$

$su1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

For calculation of $esu1_{\text{nominal}}$ and $y1, sh1, ft1, fy1$, it is considered

characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

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

with $fs1 = fs = 781.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 937.50$

$fy2 = 781.25$

$su2 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224
Mu = MRc (4.14) = 7.8532E+008
u = su (4.1) = 7.1537995E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

u = 1.5224730E-005

Mu = 1.0273E+009

with full section properties:

b = 250.00

d = 507.00

d' = 43.00

$v = 0.00207597$
 $N = 9867.326$
 $f_c = 37.50$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha_c = 0.00860501$
 $w_e (5.4c) = 0.01628822$
 $\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$
 The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.
 $A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$

From ((5A5), TBDY), TBDY: $\alpha_c = 0.00340037$
 α_c = confinement factor = 1.14004

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 937.50$
 $fy_1 = 781.25$
 $su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * \alpha_{se} * su_{1,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\alpha_{se} = 0.08$,

For calculation of α_{se} , y_1 , sh_1 , ft_1 , fy_1 , it is considered characteristic value $fsy_1 = f_s/1.2$, from table 5.1, TBDY.

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

with $fs_1 = f_s = 781.25$

with $E_{s1} = E_s = 200000.00$

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$

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

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

$su_2 = 0.4 * \alpha_{se} * su_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\alpha_{se} = 0.08$,

For calculation of α_{se} , y_2 , sh_2 , ft_2 , fy_2 , it is considered characteristic value $fsy_2 = f_s/1.2$, from table 5.1, TBDY.

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

```

with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < sy1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*sy2 - LHS eq.(4.5) is not satisfied
--->
v* < v*sc - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->

```

$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is satisfied

--->

* c_u (4.10) = 0.46822902

M_{Ro} (4.17) = 1.0273E+009

--->

$u = c_u$ (4.2) = 1.5224730E-005

$\mu_u = M_{Ro}$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u2} -

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

$u = 7.1537995E-005$

$\mu_u = 7.8532E+008$

with full section properties:

$b = 750.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00069199$

$N = 9867.326$

$f_c = 37.50$

α (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00860501$

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

From (5.4b), TBDY: $c_u = 0.00860501$

w_e (5.4c) = 0.01628822

$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

$p_{sh,x}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$p_{sh,y}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $c_c = 0.00340037$

c = confinement factor = 1.14004

$y_1 = 0.0025$

```

sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs1 = fs = 781.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 781.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
    2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
    v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224

```

$$\begin{aligned} \mu &= MRC(4.14) = 7.8532E+008 \\ u &= su(4.1) = 7.1537995E-005 \end{aligned}$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 503762.797$

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$

$V_{r1} = V_{col}((10.3), ASCE 41-17) = knl * V_{col0}$

$V_{col0} = 503762.797$

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

NOTE: In expression (10-3) ' V_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)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu = 788.0877$

$u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.75$

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

From (11-11), ACI 440: $V_s + V_f \leq 447481.489$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$

$V_{r2} = V_{col}((10.3), ASCE 41-17) = knl * V_{col0}$

$V_{col0} = 503762.797$

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

NOTE: In expression (10-3) ' V_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)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu = 788.0877$

$u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

Vs1 = 287979.327 is calculated for section web, with:

d = 440.00

Av = 157079.633

fy = 625.00

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 130899.694 is calculated for section flange, with:

d = 200.00

Av = 157079.633

fy = 625.00

s = 150.00

Vs2 is multiplied by Col2 = 1.00

s/d = 0.75

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

From (11-11), ACI 440: Vs + Vf <= 447481.489

bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

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 = 37.50

New material of Primary Member: Steel Strength, fs = fsm = 625.00

Concrete Elasticity, Ec = 28781.504

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 = 781.25

#####

Max Height, Hmax = 550.00

Min Height, Hmin = 250.00

Max Width, Wmax = 750.00

Min Width, Wmin = 250.00

Eccentricity, Ecc = 250.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.14004

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lo_u, min >= 1)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = 3.6907929E-008

EDGE -B-

Shear Force, $V_b = -3.6907929E-008$

BOTH EDGES

Axial Force, $F = -9867.326$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1231.504$

-Compression: $As_{c,com} = 1231.504$

-Middle: $As_{mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.36361$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.5430E+009$

$Mu_{1+} = 1.5430E+009$, 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

$Mu_{1-} = 1.5430E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.5430E+009$

$Mu_{2+} = 1.5430E+009$, 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

$Mu_{2-} = 1.5430E+009$, 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:

$\phi_u = 6.9461383E-005$

$M_u = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00860501$

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

From (5.4b), TBDY: $\phi_u = 0.00860501$

$\phi_{ue} (5.4c) = 0.01628822$

$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{sh,min} = \text{Min}(\phi_{sh,x}, \phi_{sh,y}) = 0.00271274$

$\phi_{sh,x} (5.4d, \text{TBDY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00
fywe = 781.25
fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004

y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032

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

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032

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

lo/lou,min = lb/d = 1.00

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

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

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

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

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

with fsv = fs = 781.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561

2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561

v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352

and confined core properties:

b = 190.00

$d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19945845$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19945845$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->

$s_u (4.8) = 0.34839091$
 $M_u = M_{Rc} (4.15) = 1.5430E+009$
 $u = s_u (4.1) = 6.9461383E-005$

Calculation of ratio l_b/d

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

Calculation of M_{u1} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.9461383E-005$
 $M_u = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $f_c = 37.50$
 $cc (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $w_e (5.4c) = 0.01628822$
 $ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
 The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.
 $A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A.5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with fsv = fs = 781.25

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561

2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561

v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 42.75139

cc (5A.5, TBDY) = 0.00340037

c = confinement factor = 1.14004

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19945845$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19945845$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.43555212$$

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

--->
v < v_{s,y2} - LHS eq.(4.5) is not satisfied

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

$$\mu_u(4.8) = 0.34839091$$

$$M_u = M_{Rc}(4.15) = 1.5430E+009$$

$$u = \mu_u(4.1) = 6.9461383E-005$$

Calculation of ratio l_b/l_d

Adequate Lap Length: l_b/l_d >= 1

Calculation of Mu₂₊

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

$$u = 6.9461383E-005$$

$$M_u = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00860501$$

$$\mu_{ue}(5.4c) = 0.01628822$$

$$\mu_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf}, A_{conf,min} and A_{conf,max} are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A_{conf,max} = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

A_{conf,min} = 110400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A_{conf,max} by a length equal to half the clear spacing between hoops.

A_{noConf} = 95733.333 is the unconfined core area which is equal to b_i²/6 as defined at (A.2).

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00271274$$

$$\mu_{sh,x}(5.4d, TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$\mu_{sh,y}(5.4d, TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$f_{ce} = 37.50$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 937.50$
 $fy_1 = 781.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1, \text{nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_1, \text{nominal} = 0.08$,
 For calculation of $esu_1, \text{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 781.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2, \text{nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_2, \text{nominal} = 0.08$,
 For calculation of $esu_2, \text{nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 781.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 937.50$
 $fy_v = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv, \text{nominal} ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv, \text{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv, \text{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.1451561$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.1451561$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 42.75139$
 $cc (5A.5, \text{TBDY}) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.19945845$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.19945845$
 $v = Asl, \text{mid}/(b * d) * (fsv/fc) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

```

---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is satisfied
---->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 6.9461383E-005
Mu = 1.5430E+009

with full section properties:

```

b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
N = 9867.326

```

fc = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00860501

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

From (5.4b), TBDY: cu = 0.00860501

we (5.4c) = 0.01628822

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max by a length

equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008


```

ft1 = 937.50
fy1 = 781.25
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs1 = fs = 781.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 781.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
    2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
    v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->

```

$\mu (4.8) = 0.34839091$
 $\mu = \mu_{RC} (4.15) = 1.5430E+009$
 $u = \mu (4.1) = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 754389.565$

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

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

$V_{Col0} = 754389.565$

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

NOTE: In expression (10-3) ' V_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)

$f'_c = 37.50$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu = 0.45248062$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$

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

$V_{Col0} = 754389.565$

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

NOTE: In expression (10-3) ' V_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)

$f'_c = 37.50$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu = 0.45236986$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$b_w = 250.00$

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rctcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -330176.506$

Shear Force, $V_2 = -2853.907$

Shear Force, $V_3 = 169.0106$

Axial Force, $F = -10499.307$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten} = 2261.947$

-Compression: $Asl_{com} = 829.3805$

-Middle: $Asl_{mid} = 2060.885$

Mean Diameter of Tension Reinforcement, $DbL = 17.77778$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0$ $u = 0.04848363$

$u = y + p = 0.04848363$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.01040803$ ((4.29), Biskinis Phd))

$My = 7.7150E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1953.584

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.8270E+013$

factor = 0.30

$A_g = 262500.00$

$f_c' = 37.50$

$N = 10499.307$

$E_c * I_g = 1.6090E+014$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{ten} = 1.0190935E-005$

with $f_y = 625.00$

$d = 507.00$

$y = 0.3951774$

$A = 0.04078115$

$B = 0.02735246$

with $pt = 0.01784573$

$pc = 0.00654344$

$pv = 0.01625945$

$N = 10499.307$

$b = 250.00$

" = 0.08481262

$y_{comp} = 1.1708664E-005$

with $f_c = 37.50$

$E_c = 28781.504$

$y = 0.39507084$

$A = 0.04047201$

$B = 0.02721993$

with $E_s = 200000.00$

Calculation of ratio l_b/l_d

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

- Calculation of p -

From table 10-8: $p = 0.03807561$

with:

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

shear control ratio $V_y E / V_{col} E = 1.35949$

$d = 507.00$

$s = 0.00$

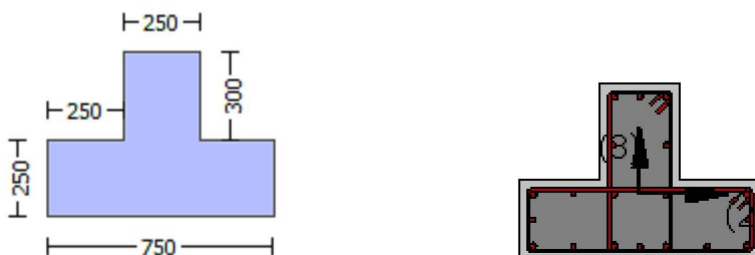
$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = A_v * L_{stir} / (A_g * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of every stirrup
 $L_{stir} = 1360.00$, is the total Length of all stirrups parallel to loading (shear) direction
 The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution
 where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength
 All these variables have already been given in Shear control ratio calculation.
 $NUD = 10499.307$
 $A_g = 262500.00$
 $f_{cE} = 37.50$
 $f_{yE} = f_{yIE} = 0.00$
 $\rho_l = \text{Area_Tot_Long_Rein} / (b \cdot d) = 0.04064862$
 $b = 250.00$
 $d = 507.00$
 $f_{cE} = 37.50$

 End Of Calculation of Chord Rotation Capacity for element: column TC1 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 V_{Rd}
 Edge: Start
 Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column TC1 of floor 1
 At local axis: 3
 Integration Section: (a)
 Section Type: rctcs

Constant Properties

 Knowledge Factor, $= 1.00$

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, $f_c = f_{c_lower_bound} = 25.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 28781.504$
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, $f_c = f_{cm} = 37.50$
New material: Steel Strength, $f_s = f_{sm} = 625.00$

Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 250.00$
Eccentricity, $E_{cc} = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -330176.506$
Shear Force, $V_a = 169.0106$
EDGE -B-
Bending Moment, $M_b = -176497.263$
Shear Force, $V_b = -169.0106$
BOTH EDGES
Axial Force, $F = -10499.307$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 2261.947$
-Compression: $A_{sl,com} = 829.3805$
-Middle: $A_{sl,mid} = 2060.885$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 404651.555$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 404651.555$
 $V_{CoI} = 404651.555$
 $k_n = 1.00$
displacement_ductility_demand = 0.00076366

NOTE: In expression (10-3) ' V_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)
 $f'_c = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 4.00$
 $M_u = 330176.506$
 $V_u = 169.0106$
 $d = 0.8 \cdot h = 440.00$

$N_u = 10499.307$
 $A_g = 137500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 335103.216$
 where:
 $V_{s1} = 230383.461$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 104719.755$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.75$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 365367.106$
 $bw = 250.00$

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 $\theta = 7.9482364E-006$
 $\phi_y = (M_y * L_s / 3) / E_{eff} = 0.01040803$ ((4.29), Biskinis Phd))
 $M_y = 7.7150E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1953.584
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.8270E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10499.307$
 $E_c * I_g = 1.6090E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$\phi_y = \min(\phi_{y_ten}, \phi_{y_com})$
 $\phi_{y_ten} = 1.0190935E-005$
 with $f_y = 625.00$
 $d = 507.00$
 $\phi_y = 0.3951774$
 $A = 0.04078115$
 $B = 0.02735246$
 with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10499.307$
 $b = 250.00$
 $\phi_y = 0.08481262$
 $\phi_{y_comp} = 1.1708664E-005$
 with $f_c = 37.50$
 $E_c = 28781.504$
 $\phi_y = 0.39507084$
 $A = 0.04047201$
 $B = 0.02721993$
 with $E_s = 200000.00$

Calculation of ratio l_b/l_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

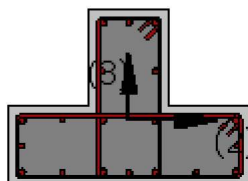
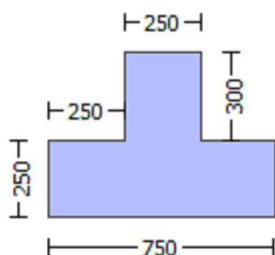
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, Hmax = 550.00
 Min Height, Hmin = 250.00
 Max Width, Wmax = 750.00
 Min Width, Wmin = 250.00
 Eccentricity, Ecc = 250.00
 Cover Thickness, c = 25.00
 Mean Confinement Factor overall section = 1.14004
 Element Length, L = 3000.00
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = 0.00014703$
 EDGE -B-
 Shear Force, $V_b = -0.00014703$
 BOTH EDGES
 Axial Force, $F = -9867.326$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 2261.947$
 -Compression: $A_{st,com} = 829.3805$
 -Middle: $A_{st,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.35949$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.0273E+009$
 $\mu_{u1+} = 1.0273E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 7.8532E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.0273E+009$
 $\mu_{u2+} = 1.0273E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $\mu_{u2-} = 7.8532E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.5224730E-005$
 $M_u = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$

$f_c = 37.50$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.00860501$
 $w_e (5.4c) = 0.01628822$
 $\alpha_{se} = \text{Max}(((\alpha_{conf,max} - \alpha_{noconf}) / \alpha_{conf,max}) * (\alpha_{conf,min} / \alpha_{conf,max}), 0) = 0.28820848$
 The definitions of α_{noconf} , $\alpha_{conf,min}$ and $\alpha_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $\alpha_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $\alpha_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $\alpha_{conf,max}$ by a length equal to half the clear spacing between hoops.
 $\alpha_{noconf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\alpha_{sh,min} = \text{Min}(\alpha_{sh,x}, \alpha_{sh,y}) = 0.00271274$

$\alpha_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$\alpha_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5A5), TBDY), TBDY: $\alpha_c = 0.00340037$
 α_c = confinement factor = 1.14004
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 937.50$
 $fy_1 = 781.25$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * \alpha_{su1_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\alpha_{su1_nominal} = 0.08$,
 For calculation of $\alpha_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 781.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * \alpha_{su2_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $\alpha_{su2_nominal} = 0.08$,
 For calculation of $\alpha_{su2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 781.25$
 with $Es_2 = Es = 200000.00$

```

yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
    2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
    v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
    2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
    v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
--->

```

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is satisfied

--->

*cu (4.10) = 0.46822902

M_{Ro} (4.17) = 1.0273E+009

--->

u = cu (4.2) = 1.5224730E-005

Mu = M_{Ro}

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

u = 7.1537995E-005

Mu = 7.8532E+008

with full section properties:

b = 750.00

d = 507.00

d' = 43.00

v = 0.00069199

N = 9867.326

f_c = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00860501

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

From (5.4b), TBDY: cu = 0.00860501

we (5.4c) = 0.01628822

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max by a length

equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to bi²/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

```

fy1 = 781.25
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs1 = fs = 781.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 781.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224
Mu = MRc (4.14) = 7.8532E+008
u = su (4.1) = 7.1537995E-005

```

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$\mu = 1.5224730E-005$$

$$\mu_{2+} = 1.0273E+009$$

with full section properties:

$$b = 250.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$\nu = 0.00207597$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_{2+} = \text{shear_factor} * \text{Max}(\mu_{2+}, \mu_{2+}) = 0.00860501$$

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

$$\text{From (5.4b), TB DY: } \mu_{2+} = 0.00860501$$

$$\mu_{2+} (5.4c) = 0.01628822$$

$$\mu_{2+} = \text{Max}(((A_{\text{conf,max}} - A_{\text{noConf}})/A_{\text{conf,max}}) * (A_{\text{conf,min}}/A_{\text{conf,max}}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{\text{conf,min}}$ and $A_{\text{conf,max}}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max}} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{\text{conf,min}} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max}}$ by a length equal to half the clear spacing between hoops.

$A_{\text{noConf}} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{2+, \text{min}} = \text{Min}(\mu_{2+, x}, \mu_{2+, y}) = 0.00271274$$

$$\mu_{2+, x} (5.4d, \text{TB DY}) = L_{\text{stir}} * A_{\text{stir}} / (A_{\text{sec}} * s) = 0.00271274$$

$$L_{\text{stir}} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{\text{stir}} (\text{stirrups area}) = 78.53982$$

$$A_{\text{sec}} (\text{section area}) = 262500.00$$

$$\mu_{2+, y} (5.4d, \text{TB DY}) = L_{\text{stir}} * A_{\text{stir}} / (A_{\text{sec}} * s) = 0.00351061$$

$$L_{\text{stir}} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{\text{stir}} (\text{stirrups area}) = 78.53982$$

$$A_{\text{sec}} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{2+} = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs1 = fs = 781.25$
with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs2 = fs = 781.25$
with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 781.25$
with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.37178611$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.13632157$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.33873846$
and confined core properties:
 $b = 190.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.51995906$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.19065166$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.47374048$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < vs, y2$ - LHS eq.(4.5) is not satisfied
--->
 $v < vs, c$ - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
--->
 $v < s, y1$ - LHS eq.(4.7) is not satisfied
--->
 $v < vc, y1$ - RHS eq.(4.6) is satisfied

```

---->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
---->
*cu (4.10) = 0.46822902
MRo (4.17) = 1.0273E+009
---->
u = cu (4.2) = 1.5224730E-005
Mu = MRo
-----

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

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

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 7.1537995E-005
Mu = 7.8532E+008
-----

with full section properties:
b = 750.00
d = 507.00
d' = 43.00
v = 0.00069199
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length

```


equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

Shear_factor = 1.00

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

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

Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with fsv = fs = 781.25

with $E_s = E_s = 200000.00$
 $1 = A_{s,ten}/(b*d)*(f_s1/f_c) = 0.04544052$
 $2 = A_{s,com}/(b*d)*(f_s2/f_c) = 0.1239287$
 $v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.11291282$
 and confined core properties:
 $b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = A_{s,ten}/(b*d)*(f_s1/f_c) = 0.05249828$
 $2 = A_{s,com}/(b*d)*(f_s2/f_c) = 0.14317713$
 $v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.13045028$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $\mu_u (4.9) = 0.1177224$
 $M_u = M_{Rc} (4.14) = 7.8532E+008$
 $u = \mu_u (4.1) = 7.1537995E-005$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 503762.797$

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$

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

$V_{Col0} = 503762.797$

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

NOTE: In expression (10-3) ' V_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)

$f_c' = 37.50$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 788.0877$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.75$

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

From (11-11), ACI 440: $V_s + V_f \leq 447481.489$

bw = 250.00

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 503762.797$
 $k_{nl} = 1$ (zero step-static loading)

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

= 1 (normal-weight concrete)
 $f'_c = 37.50$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 788.0877$
 $V_u = 0.00014703$
 $d = 0.8 * h = 440.00$
 $N_u = 9867.326$
 $A_g = 137500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$
where:
 $V_{s1} = 287979.327$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 130899.694$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.75$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 447481.489$
 $bw = 250.00$

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

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, $f_c = f_{cm} = 37.50$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 28781.504$
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, $f_s = 1.25 * f_{sm} = 781.25$

Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 250.00$
 Eccentricity, $Ecc = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.14004
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 2
 EDGE -A-
 Shear Force, $V_a = 3.6907929E-008$
 EDGE -B-
 Shear Force, $V_b = -3.6907929E-008$
 BOTH EDGES
 Axial Force, $F = -9867.326$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1231.504$
 -Compression: $As_{l,com} = 1231.504$
 -Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.36361$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.5430E+009$
 $\mu_{u1+} = 1.5430E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.5430E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.5430E+009$
 $\mu_{u2+} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 6.9461383E-005$
 $\mu_u = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $f_c = 37.50$
 $\phi_c (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$

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

From (5.4b), TBDY: $cu = 0.00860501$

we (5.4c) = 0.01628822

$ase = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

psh,x ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

psh,y ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$fy_{we} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

c = confinement factor = 1.14004

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 937.50$

$fy1 = 781.25$

$su1 = 0.032$

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

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

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

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

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

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

with $fs1 = fs = 781.25$

with $Es1 = Es = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 937.50$

$fy2 = 781.25$

$su2 = 0.032$

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

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

$su2 = 0.4 * esu2_{nominal}$ ((5.5), TBDY) = 0.032

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

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

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

with $fs2 = fs = 781.25$

with $Es2 = Es = 200000.00$

$yv = 0.0025$

$shv = 0.008$

```

ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
    c = confinement factor = 1.14004
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
    2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
    v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005
-----

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

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 6.9461383E-005
Mu = 1.5430E+009
-----

with full section properties:
b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

```

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

su2 = $0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b * d) * (fs1/fc) = 0.1451561$
 $2 = Asl_{com}/(b * d) * (fs2/fc) = 0.1451561$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.31697352$
 and confined core properties:

$b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl_{ten}/(b * d) * (fs1/fc) = 0.19945845$
 $2 = Asl_{com}/(b * d) * (fs2/fc) = 0.19945845$
 $v = Asl_{mid}/(b * d) * (fsv/fc) = 0.43555212$

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

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 ---->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 ---->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/l_d

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

Calculation of $Mu2+$

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.9461383E-005$
 $Mu = 1.5430E+009$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00148871$
 $N = 9867.326$
 $fc = 37.50$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
 The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization
 of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
 "Theoretical Stress-Strain Model for Confined Concrete."
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max by a length equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

For calculation of $\epsilon_{suv_nominal}$ and γ_v , Δv , Δf_v , Δf_y , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , Δf_1 , Δf_y , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 781.25$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.1451561$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.1451561$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.31697352$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 42.75139

cc (5A.5, TBDY) = 0.00340037

c = confinement factor = 1.14004

$1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.19945845$

$2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19945845$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.43555212$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

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

--->

μ_u (4.8) = 0.34839091

$M_u = M_{Rc}$ (4.15) = 1.5430E+009

$u = \mu_u$ (4.1) = 6.9461383E-005

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 6.9461383E-005$

$M_u = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

cc (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00860501$

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

From (5.4b), TBDY: $\mu_u = 0.00860501$

μ_{ue} (5.4c) = 0.01628822

$\mu_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) \cdot (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00
fywe = 781.25
fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004

y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032

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

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

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

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

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

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

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with fsv = fs = 781.25

with Esv = Es = 200000.00

```

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 754389.565

Calculation of Shear Strength at edge 1, Vr1 = 754389.565
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 754389.565
knl = 1 (zero step-static loading)

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

```

= 1 (normal-weight concrete)
fc' = 37.50, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.45248062
Vu = 3.6907929E-008
d = 0.8*h = 600.00
Nu = 9867.326
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 523598.776
where:
Vs1 = 130899.694 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.75
Vs2 = 392699.082 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 625.00
s = 150.00
Vs2 is multiplied by Col2 = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00

```

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$
 $bw = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 754389.565$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' V_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)
 $f'_c = 37.50$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.45236986$
 $V_u = 3.6907929E-008$
 $d = 0.8 * h = 600.00$
 $N_u = 9867.326$
 $A_g = 187500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$
where:
 $V_{s1} = 130899.694$ is calculated for section web, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.75$
 $V_{s2} = 392699.082$ is calculated for section flange, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 610202.031$
 $bw = 250.00$

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rctcs

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, $f_c = f_{cm} = 37.50$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 28781.504$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 250.00$
Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -8.7997E+006$
Shear Force, $V2 = -2853.907$
Shear Force, $V3 = 169.0106$
Axial Force, $F = -10499.307$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1231.504$
-Compression: $A_{st,com} = 1231.504$
-Middle: $A_{st,mid} = 2689.203$
Mean Diameter of Tension Reinforcement, $D_bL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.05230344$
 $u = y + p = 0.05230344$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01025899$ ((4.29), Biskinis Phd))
 $M_y = 7.9116E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3083.371
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 7.9262E+013$
factor = 0.30
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10499.307$
 $E_c * I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.3527299E-006$
with $f_y = 625.00$
 $d = 707.00$
 $y = 0.30422276$
 $A = 0.02924476$
 $B = 0.01555635$
with $p_t = 0.00696749$
 $p_c = 0.00696749$
 $p_v = 0.01521473$
 $N = 10499.307$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0917443E-005$
with $f_c = 37.50$
 $E_c = 28781.504$

y = 0.3038435
A = 0.02902307
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.04204445

with:

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

shear control ratio $V_{yE}/V_{CoIE} = 1.36361$

d = 707.00

s = 0.00

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

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1760.00$, is the total Length of all stirrups parallel to loading (shear) direction

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

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

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

NUD = 10499.307

$A_g = 262500.00$

$f_{cE} = 37.50$

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

$p_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.02914971$

b = 250.00

d = 707.00

$f_{cE} = 37.50$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

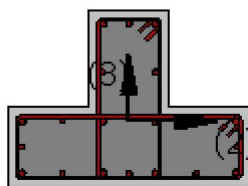
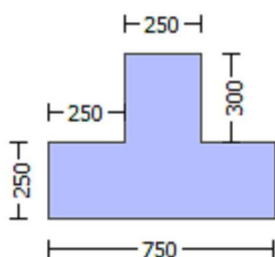
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$

New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_c = f_{cm} = 37.50$

New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -8.7997E+006$

Shear Force, $V_a = -2853.907$

EDGE -B-

Bending Moment, $M_b = 235710.829$

Shear Force, $V_b = 2853.907$

BOTH EDGES

Axial Force, $F = -10499.307$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten} = 1231.504$
-Compression: $Asl_{com} = 1231.504$
-Middle: $Asl_{mid} = 2689.203$

Mean Diameter of Tension Reinforcement, $DbL_{ten} = 17.60$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 607802.664$

V_n ((10.3), ASCE 41-17) = $knI \cdot V_{ColO} = 607802.664$

$V_{Col} = 607802.664$

$knI = 1.00$

$displacement_ductility_demand = 0.01751901$

NOTE: In expression (10-3) ' V_s ' is replaced by ' $V_s + V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$fc' = 25.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 235710.829$

$V_u = 2853.907$

$d = 0.8 \cdot h = 600.00$

$N_u = 10499.307$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 104719.755$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 314159.265$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 498227.872$

$bw = 250.00$

$displacement_ductility_demand$ is calculated as $\frac{V_u}{V_s + V_f}$

- Calculation of $\frac{V_u}{V_s + V_f}$ for END B -
for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 1.7486781E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00099816$ ((4.29), Biskinis Phd))

$M_y = 7.9116E+008$

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

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 7.9262E+013$

$factor = 0.30$

$A_g = 262500.00$

$fc' = 37.50$

$N = 10499.307$

$E_c \cdot I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

```
y = Min( y_ten, y_com)
y_ten = 6.3527299E-006
with fy = 625.00
d = 707.00
y = 0.30422276
A = 0.02924476
B = 0.01555635
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10499.307
b = 250.00
" = 0.06082037
y_comp = 1.0917443E-005
with fc = 37.50
Ec = 28781.504
y = 0.3038435
A = 0.02902307
B = 0.01546131
with Es = 200000.00
```

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

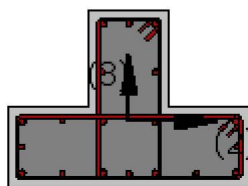
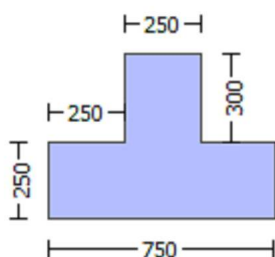
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $E_{cc} = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = 0.00014703$

EDGE -B-

Shear Force, $V_b = -0.00014703$

BOTH EDGES

Axial Force, $F = -9867.326$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 0.00$

-Compression: $A_{sc} = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 2261.947$

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

-Middle: $A_{sl,mid} = 2060.885$

Calculation of Shear Capacity ratio , $V_e/V_r = 1.35949$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.0273\text{E}+009$

$M_{u1+} = 1.0273\text{E}+009$, 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

$M_{u1-} = 7.8532\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.0273\text{E}+009$

$M_{u2+} = 1.0273\text{E}+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 7.8532\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 1.5224730\text{E}-005$

$M_u = 1.0273\text{E}+009$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$\nu = 0.00207597$

$N = 9867.326$

$f_c = 37.50$

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

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00860501$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00860501$

$\phi_{we} \text{ (5.4c)} = 0.01628822$

$\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$

$\phi_{psh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\phi_{psh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

```

From ((5A.5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004
y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 781.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->

```

```

v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < vs,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*,y2 - LHS eq.(4.6) is not satisfied
---->
v* < v*,y1 - RHS eq.(4.6) is satisfied
---->
*cu (4.10) = 0.46822902
MRo (4.17) = 1.0273E+009
---->
u = cu (4.2) = 1.5224730E-005
Mu = MRo

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

u = 7.1537995E-005

Mu = 7.8532E+008

with full section properties:

b = 750.00

d = 507.00

d' = 43.00

v = 0.00069199

N = 9867.326

fc = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00860501

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

From (5.4b), TBDY: $c_u = 0.00860501$

w_e (5.4c) = 0.01628822

$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

 $p_{sh,x}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $p_{sh,y}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $c_c = 0.00340037$

c = confinement factor = 1.14004

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 937.50$

$fy_1 = 781.25$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 937.50$

$fy_2 = 781.25$

$su_2 = 0.032$

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

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

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv,ftv,fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1,ft1,fy1$, are also multiplied by $Min(1,1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282$

and confined core properties:

$b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028$

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

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

--->
 $su (4.9) = 0.1177224$
 $Mu = MRc (4.14) = 7.8532E+008$
 $u = su (4.1) = 7.1537995E-005$

Calculation of ratio lb/ld

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

Calculation of $Mu2+$

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

$u = 1.5224730E-005$
 $Mu = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$
 $fc = 37.50$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.00860501$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00860501$
 $we (5.4c) = 0.01628822$
 $ase = Max(((Aconf,max - AnoConf)/Aconf,max)*(Aconf,min/Aconf,max), 0) = 0.28820848$
 The definitions of $AnoConf$, $Aconf,min$ and $Aconf,max$ are derived from generalization
 of the rectangular sections confinement, which is expressed by (5.4d).
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
 "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

$psh,x \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$psh,y \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$

c = confinement factor = 1.14004

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 937.50$

$fy_1 = 781.25$

$su_1 = 0.032$

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

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

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 937.50$

$fy_2 = 781.25$

$su_2 = 0.032$

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

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

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 937.50$

$fy_v = 781.25$

$su_v = 0.032$

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

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

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

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

```

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY
For calculation of  $e_{suv\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $f_{yv}$ , it is considered
characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.
 $y_1$ ,  $sh_1$ ,  $ft_1$ ,  $f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.
with  $f_{sv} = f_s = 781.25$ 
with  $E_{sv} = E_s = 200000.00$ 
1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.37178611$ 
2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.13632157$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.33873846$ 
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 =  $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.51995906$ 
2 =  $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19065166$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.47374048$ 
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $\phi_{cu}$  (4.10) = 0.38433228
 $M_{Rc}$  (4.17) = 9.9628E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$ 
-  $N_1$ ,  $N_2$ ,  $v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$ 
- parameters of confined concrete, fcc, cc, used in lieu of  $f_c$ ,  $\phi_{cu}$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is not satisfied
---->
 $v^* < v^*_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $\phi^*_{cu}$  (4.10) = 0.46822902
 $M_{Ro}$  (4.17) = 1.0273E+009
---->
u =  $\phi_{cu}$  (4.2) = 1.5224730E-005
 $\mu_u = M_{Ro}$ 
-----

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Calculation of ratio l_b/l_d

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

Calculation of μ_2 -

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

$$\mu = 7.1537995E-005$$

$$\mu_u = 7.8532E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00069199$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00860501$$

$$\mu_{ue} \text{ (5.4c)} = 0.01628822$$

$$\mu_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00271274$

$$\mu_{psh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$\mu_{psh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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

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

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

```

with fs1 = fs = 781.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224
Mu = MRc (4.14) = 7.8532E+008
u = su (4.1) = 7.1537995E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 503762.797

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$

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

$V_{ColO} = 503762.797$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 788.0877$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.75$

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

From (11-11), ACI 440: $V_s + V_f \leq 447481.489$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$

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

$V_{ColO} = 503762.797$

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

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

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 788.0877$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 418879.02$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.34090909$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

Vs2 is multiplied by Col2 = 1.00
s/d = 0.75
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 447481.489
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rctcs

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, $f_c = f_{cm} = 37.50$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 28781.504$
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, $f_s = 1.25 \cdot f_{sm} = 781.25$

Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 250.00$
Eccentricity, $E_{cc} = 250.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.14004
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 3.6907929E-008$
EDGE -B-
Shear Force, $V_b = -3.6907929E-008$
BOTH EDGES
Axial Force, $F = -9867.326$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1231.504$
-Compression: $A_{sl,com} = 1231.504$
-Middle: $A_{sl,mid} = 2689.203$

Calculation of Shear Capacity ratio , $V_e/V_r = 1.36361$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$ with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.5430E+009$

$\mu_{1+} = 1.5430E+009$, 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

$\mu_{1-} = 1.5430E+009$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.5430E+009$

$\mu_{2+} = 1.5430E+009$, 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

$\mu_{2-} = 1.5430E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

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

$\phi_u = 6.9461383E-005$

$\mu_u = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

ω (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00860501$

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

From (5.4b), TBDY: $\phi_u = 0.00860501$

$\phi_{ue} = 0.01628822$

$\phi_{ase} = \text{Max}((A_{conf,max} - A_{noConf})/A_{conf,max} * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$

$\phi_{psh,x}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\phi_{psh,y}$ ((5.4d), TBDY) = $L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $\phi_c = 0.00340037$

ϕ_c = confinement factor = 1.14004

```

y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs1 = fs = 781.25
    with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fs2 = fs = 781.25
    with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE41-17.
    with fsv = fs = 781.25
    with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->

```


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

--->

$\mu_u(4.8) = 0.34839091$

$\mu_u = M_{Rc}(4.15) = 1.5430E+009$

$u = \mu_u(4.1) = 6.9461383E-005$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u1} -

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

$u = 6.9461383E-005$

$\mu_u = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.00860501$

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

From (5.4b), TB DY: $\mu_u = 0.00860501$

$\mu_{ue}(5.4c) = 0.01628822$

$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00271274$

$\mu_{sh,x}(5.4d, \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$\mu_{sh,y}(5.4d, \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 781.25$

$f_{ce} = 37.50$

From ((5.A5), TB DY), TB DY: $\alpha_c = 0.00340037$

α_c = confinement factor = 1.14004

$y_1 = 0.0025$

$sh_1 = 0.008$

$f_{t1} = 937.50$

$f_{y1} = 781.25$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
 For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 781.25$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 781.25$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 937.50$
 $fy_v = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Es_v = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/f_c) = 0.1451561$
 $2 = Asl_{com}/(b*d) * (fs_2/f_c) = 0.1451561$
 $v = Asl_{mid}/(b*d) * (fsv/f_c) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl_{ten}/(b*d) * (fs_1/f_c) = 0.19945845$
 $2 = Asl_{com}/(b*d) * (fs_2/f_c) = 0.19945845$
 $v = Asl_{mid}/(b*d) * (fsv/f_c) = 0.43555212$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is satisfied
 --->
 $su (4.8) = 0.34839091$
 $Mu = MRc (4.15) = 1.5430E+009$
 $u = su (4.1) = 6.9461383E-005$

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$\mu = 6.9461383E-005$$

$$\mu_{2+} = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$\nu = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_{2+} = \text{shear_factor} * \text{Max}(\mu_{2+}, \mu_{2+}) = 0.00860501$$

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

$$\text{From (5.4b), TB DY: } \mu_{2+} = 0.00860501$$

$$\mu_{2+} (5.4c) = 0.01628822$$

$$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{sh,min} = \text{Min}(\mu_{sh,x}, \mu_{sh,y}) = 0.00271274$$

$$\mu_{sh,x} (5.4d, \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$\mu_{sh,y} (5.4d, \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_{2+} = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

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

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

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs1 = fs = 781.25$
with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fs2 = fs = 781.25$
with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
with $fsv = fs = 781.25$
with $Esv = Es = 200000.00$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.1451561$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.1451561$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.31697352$
and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc \text{ (5A.2, TBDY)} = 42.75139$
 $cc \text{ (5A.5, TBDY)} = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.19945845$
 $2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.19945845$
 $v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.43555212$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < vs, y2$ - LHS eq.(4.5) is not satisfied
--->
 $v < vs, c$ - RHS eq.(4.5) is satisfied
--->
 $su \text{ (4.8)} = 0.34839091$
 $Mu = MRc \text{ (4.15)} = 1.5430E+009$
 $u = su \text{ (4.1)} = 6.9461383E-005$

Calculation of ratio lb/ld

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

Calculation of Mu2-

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

$$\mu = 6.9461383E-005$$

$$Mu = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } c_u: c_u = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00860501$$

$$w_e \text{ (5.4c)} = 0.01628822$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

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$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

$$p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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

$$\text{with } fs_1 = fs = 781.25$$

```

with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 754389.565

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

$V_{r1} = V_{col} \text{ ((10.3), ASCE 41-17)} = knl * V_{col0}$

$V_{col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$fc' = 37.50$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.45248062$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$bw = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$

$V_{r2} = V_{col} \text{ ((10.3), ASCE 41-17)} = knl * V_{col0}$

$V_{col0} = 754389.565$

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

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

= 1 (normal-weight concrete)

$fc' = 37.50$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.45236986$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

s = 150.00
Vs2 is multiplied by Col2 = 1.00
s/d = 0.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 610202.031
bw = 250.00

End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rctcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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, $f_c = f_{cm} = 37.50$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 28781.504$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 550.00$
Min Height, $H_{min} = 250.00$
Max Width, $W_{max} = 750.00$
Min Width, $W_{min} = 250.00$
Eccentricity, $E_{cc} = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -176497.263$
Shear Force, $V_2 = 2853.907$
Shear Force, $V_3 = -169.0106$
Axial Force, $F = -10499.307$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 2261.947$
-Compression: $A_{st,com} = 829.3805$
-Middle: $A_{st,mid} = 2060.885$
Mean Diameter of Tension Reinforcement, $DbL = 17.77778$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04363926$
 $u = \gamma + \rho = 0.04363926$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00556365 ((4.29), \text{Biskinis Phd})$
 $M_y = 7.7150E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1044.297
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 4.8270E+013$
factor = 0.30
Ag = 262500.00
fc' = 37.50
N = 10499.307
 $E_c * I_g = 1.6090E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0190935E-005$
with $f_y = 625.00$
d = 507.00
 $y = 0.3951774$
A = 0.04078115
B = 0.02735246
with $p_t = 0.01784573$
pc = 0.00654344
pv = 0.01625945
N = 10499.307
b = 250.00
" = 0.08481262
 $y_{comp} = 1.1708664E-005$
with $f_c = 37.50$
Ec = 28781.504
 $y = 0.39507084$
A = 0.04047201
B = 0.02721993
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.03807561$

with:

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

shear control ratio $V_y E / V_{col} E = 1.35949$

d = 507.00

s = 0.00

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

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1360.00$, is the total Length of all stirrups parallel to loading (shear) direction

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

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

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

NUD = 10499.307

Ag = 262500.00

fcE = 37.50

fytE = fyle = 0.00

$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.04064862$

b = 250.00

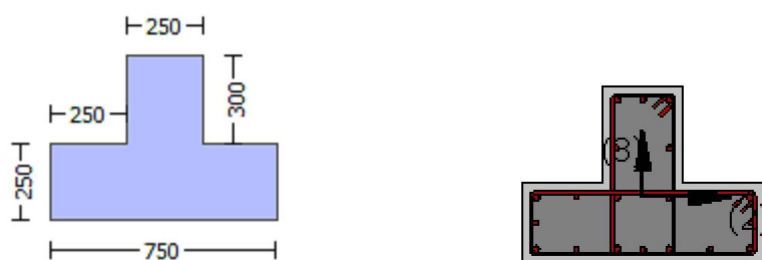
d = 507.00

fcE = 37.50

End Of Calculation of Chord Rotation Capacity for element: column TC1 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 TC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rctcs

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, $f_c = f_{c_lower_bound} = 25.00$
New material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 28781.504$
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, $f_c = f_{cm} = 37.50$
New material: Steel Strength, $f_s = f_{sm} = 625.00$

#####

Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00
Min Width, Wmin = 250.00
Eccentricity, Ecc = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -330176.506
Shear Force, Va = 169.0106
EDGE -B-
Bending Moment, Mb = -176497.263
Shear Force, Vb = -169.0106
BOTH EDGES
Axial Force, F = -10499.307
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5152.212
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 2261.947
-Compression: Asl,com = 829.3805
-Middle: Asl,mid = 2060.885
Mean Diameter of Tension Reinforcement, DbL,ten = 17.77778

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = $1.0 \cdot V_n = 452316.14$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{CoIO} = 452316.14$
 $V_{CoI} = 452316.14$
 $knl = 1.00$
 $displacement_ductility_demand = 2.7132450E-006$

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

= 1 (normal-weight concrete)
 $fc' = 25.00$, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.3734$
 $M_u = 176497.263$
 $V_u = 169.0106$
 $d = 0.8 \cdot h = 440.00$
 $N_u = 10499.307$
 $A_g = 137500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 335103.216$
where:
 $V_{s1} = 230383.461$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s1} is multiplied by Col1 = 1.00
 $s/d = 0.34090909$
 $V_{s2} = 104719.755$ is calculated for section flange, with:
 $d = 200.00$

$A_v = 157079.633$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.75$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From $(11-11)$, ACI 440: $V_s + V_f \leq 365367.106$
 $bw = 250.00$

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 $\phi = 1.5095558E-008$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00556365 ((4.29), Biskinis Phd)$
 $M_y = 7.7150E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1044.297
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.8270E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10499.307$
 $E_c * I_g = 1.6090E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 1.0190935E-005$
 with $f_y = 625.00$
 $d = 507.00$
 $y = 0.3951774$
 $A = 0.04078115$
 $B = 0.02735246$
 with $pt = 0.01784573$
 $pc = 0.00654344$
 $pv = 0.01625945$
 $N = 10499.307$
 $b = 250.00$
 $" = 0.08481262$
 $y_{comp} = 1.1708664E-005$
 with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.39507084$
 $A = 0.04047201$
 $B = 0.02721993$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

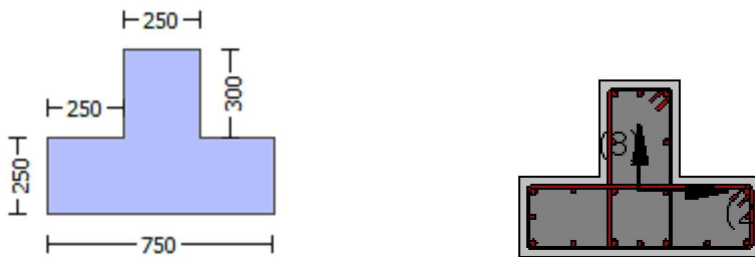
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rctcs

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, $f_c = f_{cm} = 37.50$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 28781.504$

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, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

Max Height, $H_{max} = 550.00$

Min Height, $H_{min} = 250.00$

Max Width, $W_{max} = 750.00$

Min Width, $W_{min} = 250.00$

Eccentricity, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.14004

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou}, \min \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = 0.00014703$
EDGE -B-
Shear Force, $V_b = -0.00014703$
BOTH EDGES
Axial Force, $F = -9867.326$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 2261.947$
-Compression: $As_{l,com} = 829.3805$
-Middle: $As_{l,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.35949$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 684862.956$
with
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.0273E+009$
 $\mu_{1+} = 1.0273E+009$, 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
 $\mu_{1-} = 7.8532E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.0273E+009$
 $\mu_{2+} = 1.0273E+009$, 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
 $\mu_{2-} = 7.8532E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 1.5224730E-005$
 $\mu_u = 1.0273E+009$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00207597$
 $N = 9867.326$
 $f_c = 37.50$
 $\alpha = 0.85$ (5A.5, TBDY) = 0.002
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha) = 0.00860501$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00860501$
 $\mu_{ue} = 0.01628822$
 $\alpha_{se} = \max((A_{conf,max} - A_{noConf})/A_{conf,max} * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
 $A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.
 $A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and
 is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length
 equal to half the clear spacing between hoops.
 $A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

$psh,x ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$psh,y ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5.A5), TBDY), TBDY: $cc = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 937.50$
 $fy1 = 781.25$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 781.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered

```

characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE41-17.
with  $f_{sv} = f_s = 781.25$ 
with  $E_{sv} = E_s = 200000.00$ 
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.37178611$ 
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.13632157$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.33873846$ 
and confined core properties:
 $b = 190.00$ 
 $d = 477.00$ 
 $d' = 13.00$ 
 $f_{cc} \text{ (5A.2, TBDY)} = 42.75139$ 
 $cc \text{ (5A.5, TBDY)} = 0.00340037$ 
 $c = \text{confinement factor} = 1.14004$ 
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.51995906$ 
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.19065166$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.47374048$ 
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
---->
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $c_u \text{ (4.10)} = 0.38433228$ 
 $M_{Rc} \text{ (4.17)} = 9.9628E+008$ 
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
-  $b, d, d'$  replaced by geometric parameters of the core:  $b_o, d_o, d'_o$ 
-  $N, 1, 2, v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$ 
-  $f_{cc}, cc$  parameters of confined concrete,  $f_{cc}, cc$ , used in lieu of  $f_c, e_{cu}$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is not satisfied
---->
 $v^* < v^*_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $*c_u \text{ (4.10)} = 0.46822902$ 
 $M_{Ro} \text{ (4.17)} = 1.0273E+009$ 
---->
 $u = c_u \text{ (4.2)} = 1.5224730E-005$ 
 $\mu = M_{Ro}$ 
-----

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

```


Calculation of Mu1-

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

$$\mu = 7.1537995E-005$$

$$\mu_u = 7.8532E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00069199$$

$$N = 9867.326$$

$$f_c = 37.50$$

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

$$\text{Final value of } \mu_u: \mu_u = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.00860501$$

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

$$\text{From (5.4b), TB DY: } \mu_u = 0.00860501$$

$$\mu_{ue}(5.4c) = 0.01628822$$

$$\mu_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\mu_{psh,min} = \text{Min}(\mu_{psh,x}, \mu_{psh,y}) = 0.00271274$$

$$\mu_{psh,x}((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along Y}) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$\mu_{psh,y}((5.4d), \text{TB DY}) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along X}) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 781.25$$

$$f_{ce} = 37.50$$

$$\text{From } ((5.A5), \text{TB DY}), \text{TB DY: } c_c = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 937.50$$

$$fy_1 = 781.25$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = fs = 781.25$$

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713
v = Asl,mid/(b*d)*(fsv/fc) = 0.13045028
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.1177224
Mu = MRc (4.14) = 7.8532E+008
u = su (4.1) = 7.1537995E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

u = 1.5224730E-005
Mu = 1.0273E+009

with full section properties:

b = 250.00

d = 507.00

d' = 43.00

v = 0.00207597

N = 9867.326

fc = 37.50

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00860501

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

From (5.4b), TBDY: cu = 0.00860501

we (5.4c) = 0.01628822

ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max = 188100.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max by a length

equal to half the clear spacing between hoops.

AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).

psh,min = Min(psh,x , psh,y) = 0.00271274

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274

Lstir (Length of stirrups along Y) = 1760.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

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

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

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered

characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

with fs1 = fs = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.37178611
2 = Asl,com/(b*d)*(fs2/fc) = 0.13632157
v = Asl,mid/(b*d)*(fsv/fc) = 0.33873846
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.51995906
2 = Asl,com/(b*d)*(fs2/fc) = 0.19065166
v = Asl,mid/(b*d)*(fsv/fc) = 0.47374048
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.38433228
MRc (4.17) = 9.9628E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*,y2 - LHS eq.(4.5) is not satisfied

```

```

---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is satisfied
---->
*cu (4.10) = 0.46822902
MRo (4.17) = 1.0273E+009
---->
u = cu (4.2) = 1.5224730E-005
Mu = MRo

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 7.1537995E-005
Mu = 7.8532E+008

with full section properties:

```

b = 750.00
d = 507.00
d' = 43.00
v = 0.00069199
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

```

```

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

```

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

```

s = 150.00
fywe = 781.25
fce = 37.50
From ((5A.5), TBDY), TBDY: cc = 0.00340037
c = confinement factor = 1.14004
y1 = 0.0025
sh1 = 0.008
ft1 = 937.50
fy1 = 781.25
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs1 = fs = 781.25
with Es1 = Es = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 937.50
fy2 = 781.25
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fs2 = fs = 781.25
with Es2 = Es = 200000.00
yv = 0.0025
shv = 0.008
ftv = 937.50
fyv = 781.25
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE41-17.
with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04544052
2 = Asl,com/(b*d)*(fs2/fc) = 0.1239287
v = Asl,mid/(b*d)*(fsv/fc) = 0.11291282
and confined core properties:
b = 690.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05249828
2 = Asl,com/(b*d)*(fs2/fc) = 0.14317713

```

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.13045028$$

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

--->

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

--->

$$s_u (4.9) = 0.1177224$$

$$M_u = M_{Rc} (4.14) = 7.8532E+008$$

$$u = s_u (4.1) = 7.1537995E-005$$

Calculation of ratio l_b / l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 503762.797$

Calculation of Shear Strength at edge 1, $V_{r1} = 503762.797$

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

$$V_{Col0} = 503762.797$$

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

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

= 1 (normal-weight concrete)

$$f_c' = 37.50, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M / Vd = 4.00$$

$$M_u = 788.0877$$

$$V_u = 0.00014703$$

$$d = 0.8 \cdot h = 440.00$$

$$N_u = 9867.326$$

$$A_g = 137500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 418879.02$$

where:

$V_{s1} = 287979.327$ is calculated for section web, with:

$$d = 440.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.34090909$$

$V_{s2} = 130899.694$ is calculated for section flange, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 150.00$$

V_{s2} is multiplied by $Col2 = 1.00$

$$s/d = 0.75$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 447481.489$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 503762.797$

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

$$V_{Col0} = 503762.797$$

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

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

= 1 (normal-weight concrete)

$$f_c' = 37.50, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$M/Vd = 4.00$
 $Mu = 788.0877$
 $Vu = 0.00014703$
 $d = 0.8 \cdot h = 440.00$
 $Nu = 9867.326$
 $Ag = 137500.00$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 = 418879.02$
 where:
 $Vs1 = 287979.327$ is calculated for section web, with:
 $d = 440.00$
 $Av = 157079.633$
 $fy = 625.00$
 $s = 150.00$
 $Vs1$ is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $Vs2 = 130899.694$ is calculated for section flange, with:
 $d = 200.00$
 $Av = 157079.633$
 $fy = 625.00$
 $s = 150.00$
 $Vs2$ is multiplied by $Col2 = 1.00$
 $s/d = 0.75$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 447481.489$
 $bw = 250.00$

 End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
 At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rctcs

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, $fc = fcm = 37.50$
 New material of Primary Member: Steel Strength, $fs = fsm = 625.00$
 Concrete Elasticity, $Ec = 28781.504$
 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, $fs = 1.25 \cdot fsm = 781.25$
 #####
 Max Height, $Hmax = 550.00$
 Min Height, $Hmin = 250.00$
 Max Width, $Wmax = 750.00$
 Min Width, $Wmin = 250.00$
 Eccentricity, $Ecc = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.14004
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($lo/ou, min \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6907929E-008$

EDGE -B-

Shear Force, $V_b = -3.6907929E-008$

BOTH EDGES

Axial Force, $F = -9867.326$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1231.504$

-Compression: $As_{l,com} = 1231.504$

-Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.36361$

Member Controlled by Shear ($V_e/V_r > 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.0287E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.5430E+009$

$Mu_{1+} = 1.5430E+009$, 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

$Mu_{1-} = 1.5430E+009$, 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.5430E+009$

$Mu_{2+} = 1.5430E+009$, 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

$Mu_{2-} = 1.5430E+009$, 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:

$\phi_u = 6.9461383E-005$

$Mu = 1.5430E+009$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00148871$

$N = 9867.326$

$f_c = 37.50$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00860501$

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

From (5.4b), TBDY: $\phi_u = 0.00860501$

we (5.4c) $= 0.01628822$

$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} = \min(psh_x, psh_y) = 0.00271274$

 $psh_x ((5.4d), TBDY) = L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00271274$
 L_{stir} (Length of stirrups along Y) = 1760.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

 $psh_y ((5.4d), TBDY) = L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00351061$
 L_{stir} (Length of stirrups along X) = 1360.00
 A_{stir} (stirrups area) = 78.53982
 A_{sec} (section area) = 262500.00

 $s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$

From ((5.A5), TBDY), TBDY: $cc = 0.00340037$
 c = confinement factor = 1.14004

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 937.50$
 $fy_1 = 781.25$
 $su_1 = 0.032$

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

$lo/lo_{min} = lb/l_d = 1.00$

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

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

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

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

with $fs_1 = fs = 781.25$

with $Es_1 = Es = 200000.00$

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 937.50$
 $fy_2 = 781.25$
 $su_2 = 0.032$

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

$lo/lo_{min} = lb/l_b, min = 1.00$

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

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

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

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

with $fs_2 = fs = 781.25$

with $Es_2 = Es = 200000.00$

$y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 937.50$
 $fy_v = 781.25$
 $suv = 0.032$

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

$lo/lo_{min} = lb/l_d = 1.00$

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

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

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

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

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

```

with fsv = fs = 781.25
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1451561
2 = Asl,com/(b*d)*(fs2/fc) = 0.1451561
v = Asl,mid/(b*d)*(fsv/fc) = 0.31697352
and confined core properties:
b = 190.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 42.75139
cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

```

u = 6.9461383E-005
Mu = 1.5430E+009

```

with full section properties:

```

b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

```

$$psh,x ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00271274$$

$$Lstir \text{ (Length of stirrups along Y)} = 1760.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$psh,y ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00351061$$

$$Lstir \text{ (Length of stirrups along X)} = 1360.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$fywe = 781.25$$

$$fce = 37.50$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 937.50$$

$$fy1 = 781.25$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = fs = 781.25$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 937.50$$

$$fy2 = 781.25$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = fs = 781.25$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 937.50$$

$$fyv = 781.25$$

$$suv = 0.032$$

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

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

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 781.25$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.1451561$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.1451561$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.31697352$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc(5A.2, TBDY) = 42.75139$$

$$cc(5A.5, TBDY) = 0.00340037$$

$$c = \text{confinement factor} = 1.14004$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19945845$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.19945845$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.43555212$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

$$s_u(4.8) = 0.34839091$$

$$\mu_u = M_{Rc}(4.15) = 1.5430E+009$$

$$u = s_u(4.1) = 6.9461383E-005$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u2+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.9461383E-005$$

$$\mu_u = 1.5430E+009$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00148871$$

$$N = 9867.326$$

$$f_c = 37.50$$

$$cc(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.00860501$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.00860501$$

$$\mu_{ue}(5.4c) = 0.01628822$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

The definitions of A_{noConf} , $A_{conf,min}$ and $A_{conf,max}$ are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max} = 188100.00$ is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the perimeter hoops.

$A_{conf,min} = 110400.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max}$ by a length

equal to half the clear spacing between hoops.

$A_{noConf} = 95733.333$ is the unconfined core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

$$p_{sh,x}(5.4d, TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

psh,y ((5.4d), TBDY) = $L_{stir} \cdot A_{stir} / (A_{sec} \cdot s) = 0.00351061$

Lstir (Length of stirrups along X) = 1360.00

Astir (stirrups area) = 78.53982

Asec (section area) = 262500.00

s = 150.00

fywe = 781.25

fce = 37.50

From ((5.A5), TBDY), TBDY: cc = 0.00340037

c = confinement factor = 1.14004

y1 = 0.0025

sh1 = 0.008

ft1 = 937.50

fy1 = 781.25

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = $0.4 \cdot esu1_{nominal} ((5.5), TBDY) = 0.032$

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 = 781.25

with Es1 = Es = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 937.50

fy2 = 781.25

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = $0.4 \cdot esu2_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered

characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 781.25

with Es2 = Es = 200000.00

yv = 0.0025

shv = 0.008

ftv = 937.50

fyv = 781.25

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = $0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 781.25

with Esv = Es = 200000.00

1 = $Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.1451561$

2 = $Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.1451561$

v = $Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.31697352$

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 42.75139

```

cc (5A.5, TBDY) = 0.00340037
c = confinement factor = 1.14004
1 = Asl,ten/(b*d)*(fs1/fc) = 0.19945845
2 = Asl,com/(b*d)*(fs2/fc) = 0.19945845
v = Asl,mid/(b*d)*(fsv/fc) = 0.43555212
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is satisfied
--->
su (4.8) = 0.34839091
Mu = MRc (4.15) = 1.5430E+009
u = su (4.1) = 6.9461383E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

```

u = 6.9461383E-005
Mu = 1.5430E+009

```

with full section properties:

```

b = 250.00
d = 707.00
d' = 43.00
v = 0.00148871
N = 9867.326
fc = 37.50
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00860501
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00860501
we (5.4c) = 0.01628822
ase = Max(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization
of the rectangular sections confinement, which is expressed by (5.4d).
The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)
"Theoretical Stress-Strain Model for Confined Concrete."
J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.
Aconf,max = 188100.00 is the confined core area at levels of member with hoops and
is calculated as the area of core enclosed by the center lines of the perimeter hoops.
Aconf,min = 110400.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max by a length
equal to half the clear spacing between hoops.
AnoConf = 95733.333 is the unconfined core area which is equal to bi2/6 as defined at (A.2).
psh,min = Min(psh,x , psh,y) = 0.00271274

```

```

psh,x ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00271274
Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

```

psh,y ((5.4d), TBDY) = Lstir*Astir/(Asec*s) = 0.00351061
Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

```

$s = 150.00$
 $f_{ywe} = 781.25$
 $f_{ce} = 37.50$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 937.50$
 $fy1 = 781.25$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 781.25$
 with $Es1 = Es = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 937.50$
 $fy2 = 781.25$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 781.25$
 with $Es2 = Es = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 937.50$
 $fyv = 781.25$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 781.25$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.1451561$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.1451561$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.31697352$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 42.75139$
 $cc (5A.5, TBDY) = 0.00340037$
 $c = \text{confinement factor} = 1.14004$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.19945845$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.19945845$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.43555212$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is satisfied

--->

s_u (4.8) = 0.34839091

$\mu_u = M_{Rc}$ (4.15) = 1.5430E+009

$u = s_u$ (4.1) = 6.9461383E-005

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 754389.565$

Calculation of Shear Strength at edge 1, $V_{r1} = 754389.565$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$V_{Col0} = 754389.565$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f'_c = 37.50$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.45248062$

$V_u = 3.6907929E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$

where:

$V_{s1} = 130899.694$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 392699.082$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 150.00$

V_{s2} is multiplied by $Col2 = 1.00$

$s/d = 0.25$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 610202.031$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 754389.565$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$V_{Col0} = 754389.565$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

$f_c' = 37.50$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.45236986$
 $V_u = 3.6907929E-008$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 9867.326$
 $A_g = 187500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 523598.776$
 where:
 $V_{s1} = 130899.694$ is calculated for section web, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.75$
 $V_{s2} = 392699.082$ is calculated for section flange, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 1.00$
 $s/d = 0.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 610202.031$
 $b_w = 250.00$

 End Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
 At local axis: 2

 Start Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1
 At local axis: 3
 Integration Section: (b)
 Section Type: rctcs

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 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, $f_c = f_{cm} = 37.50$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 28781.504$
 Steel Elasticity, $E_s = 200000.00$
 Max Height, $H_{max} = 550.00$
 Min Height, $H_{min} = 250.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 250.00$
 Eccentricity, $E_{cc} = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d > 1$)
 No FRP Wrapping

 Stepwise Properties

Bending Moment, $M = 235710.829$
 Shear Force, $V2 = 2853.907$
 Shear Force, $V3 = -169.0106$
 Axial Force, $F = -10499.307$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 5152.212$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{ten} = 1231.504$
 -Compression: $As_{com} = 1231.504$
 -Middle: $As_{mid} = 2689.203$
 Mean Diameter of Tension Reinforcement, $Db_L = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04304261$
 $u = y + p = 0.04304261$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00099816$ ((4.29), Biskinis Phd))
 $M_y = 7.9116E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.9262E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 37.50$
 $N = 10499.307$
 $E_c * I_g = 2.6421E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 6.3527299E-006$
 with $f_y = 625.00$
 $d = 707.00$
 $y = 0.30422276$
 $A = 0.02924476$
 $B = 0.01555635$
 with $p_t = 0.00696749$
 $p_c = 0.00696749$
 $p_v = 0.01521473$
 $N = 10499.307$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0917443E-005$
 with $f_c = 37.50$
 $E_c = 28781.504$
 $y = 0.3038435$
 $A = 0.02902307$
 $B = 0.01546131$
 with $E_s = 200000.00$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.04204445$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$

shear control ratio $V_{yE}/V_{ColOE} = 1.36361$

$d = 707.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = A_v*L_{stir}/(A_g*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00$

$A_v = 78.53982$, is the area of every stirrup

$L_{stir} = 1760.00$, is the total Length of all stirrups parallel to loading (shear) direction

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.

$N_{UD} = 10499.307$

$A_g = 262500.00$

$f_{cE} = 37.50$

$f_{yE} = f_{yIE} = 0.00$

$p_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.02914971$

$b = 250.00$

$d = 707.00$

$f_{cE} = 37.50$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (b)
