

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

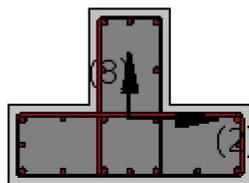
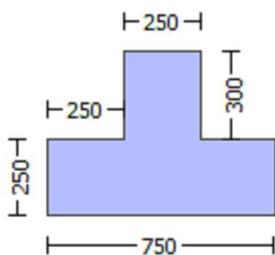
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column 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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

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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, $Ecc = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -8.5117E+006$

Shear Force, $V_a = -2785.183$

EDGE -B-

Bending Moment, $M_b = 154158.603$

Shear Force, $V_b = 2785.183$

BOTH EDGES

Axial Force, $F = -10296.313$

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: $As_{mid} = 2689.203$

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 * V_n = 513320.765$

$V_n ((10.3), ASCE 41-17) = knl * V_{CoI} = 513320.765$

$V_{CoI} = 513320.765$

$knl = 1.00$

$displacement_ductility_demand = 0.00914735$

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

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

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

$M/Vd = 4.00$

$M_u = 8.5117E+006$

$V_u = 2785.183$

$d = 0.8 * h = 600.00$

$N_u = 10296.313$

$A_g = 187500.00$

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:

$d = 200.00$

Av = 157079.633

fy = 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

Av = 157079.633

fy = 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

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 = 4.9345277E-005

$y = (My * Ls / 3) / Eleff = 0.00539449$ ((4.29), Biskinis Phd))

My = 3.9374E+008

Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 3056.073

From table 10.5, ASCE 41_17: Eleff = factor * Ec * Ig = 7.4354E+013

factor = 0.30

Ag = 262500.00

fc' = 33.00

N = 10296.313

Ec * Ig = 2.4785E+014

Calculation of Yielding Moment My

Calculation of ϕ / y and My according to Annex 7 -

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

$y_{ten} = 3.1941313E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 311.2112$

d = 707.00

y = 0.31094644

A = 0.0293369

B = 0.01564849

with pt = 0.00696749

pc = 0.00696749

pv = 0.01521473

N = 10296.313

b = 250.00

" = 0.06082037

$y_{comp} = 1.0047538E-005$

with fc = 33.00

Ec = 26999.444

y = 0.30970808

A = 0.02901732

B = 0.01546131

with Es = 200000.00

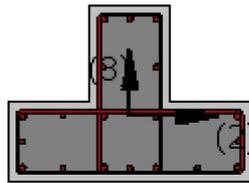
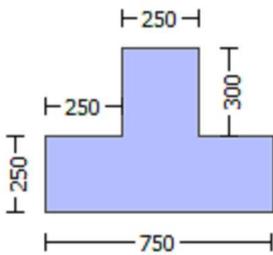
Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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 (θ)
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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

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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 = 1.00
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
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: $A_{st,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.88728525$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$
with
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 6.0162E+008$
 $\mu_{1+} = 6.0162E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{1-} = 2.9288E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 6.0162E+008$
 $\mu_{2+} = 6.0162E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{2-} = 2.9288E+008$, 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:
 $\mu = 1.5713663E-005$
 $\mu_u = 6.0162E+008$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00235905$
 $N = 9867.326$
 $f_c = 33.00$
 $\omega (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \omega) = 0.00631023$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00631023$

$$w_e (5.4c) = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$f_{yv} = 389.0139$$

$$s_{uv} = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

For calculation of $e_{suv,nominal}$ and γ_v , sh_v , ft_v , f_{y1} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1 , ft_1 , f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.21037088$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07713599$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.26806058$$

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

$$s_u (4.8) = 0.35733511$$

$$M_u = M_{Rc} (4.15) = 6.0162E+008$$

$$u = s_u (4.1) = 1.5713663E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u1 -

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

$$u = 1.1952435E-005$$

$$M_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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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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).

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

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

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

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal}$ ((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 $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

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

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

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

characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lo_{u,min} = lb/d = 0.30

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

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

considering characteristic value fs_{yv} = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and y_v, sh_v,ft_v,fy_v, it is considered characteristic value fs_{yv} = 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 = 389.0139

with Es_v = Es = 200000.00

1 = Asl_{ten}/(b*d)*(fs₁/fc) = 0.025712

2 = Asl_{com}/(b*d)*(fs₂/fc) = 0.07012363

v = Asl_{mid}/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

b = 690.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl_{ten}/(b*d)*(fs₁/fc) = 0.02970555

2 = Asl_{com}/(b*d)*(fs₂/fc) = 0.08101513

v = Asl_{mid}/(b*d)*(fsv/fc) = 0.07381378

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs_{y2} - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.15509944

Mu = MRc (4.14) = 2.9288E+008

u = su (4.1) = 1.1952435E-005

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu₂₊

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

u = 1.5713663E-005

Mu = 6.0162E+008

with full section properties:

b = 250.00

d = 507.00

d' = 43.00

v = 0.00235905

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00631023

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

From (5.4b), TBDY: cu = 0.00631023

we (5.4c) = 0.00493587

ase = Max(((Aconf,max-A_{noConf})/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848

The definitions of A_{noConf}, 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.

$A_{conf,min} = 110400.00$ 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).

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

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

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_0/l_{ou,min} = l_b/l_d = 0.30$

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_0/l_{ou,min} = l_b/l_{b,min} = 0.30$

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$l_0/l_{ou,min} = l_b/l_d = 0.30$

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

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

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

with $f_{sv} = f_s = 389.0139$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.21037088$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07713599$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.19167125$

and confined core properties:

$b = 190.00$

$d = 477.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.29421283$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10787804$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.26806058$

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) = 0.35733511

$M_u = M_{Rc}$ (4.15) = 6.0162E+008

$u = s_u$ (4.1) = 1.5713663E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u2 -

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

$u = 1.1952435E-005$

$M_u = 2.9288E+008$

with full section properties:

$b = 750.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00078635$

$N = 9867.326$

$f_c = 33.00$

cc (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00631023$

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

From (5.4b), TBDY: $cu = 0.00631023$

w_e (5.4c) = 0.00493587

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

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).

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00271274$

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

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

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

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$lo/lo_{min} = lb/ld = 0.30$

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

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 $fsy_1 = fs/1.2$, 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 $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$lo/lo_{min} = lb/lb_{min} = 0.30$

$su_2 = 0.4 * esu_{2_nominal} \text{ ((5.5), TBDY)} = 0.032$

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 $fsy_2 = fs/1.2$, 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 $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$lo/lo_{min} = lb/ld = 0.30$

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

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

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

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

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

with $fsv = fs = 389.0139$

with $Esv = Es = 200000.00$

$1 = Asl,ten/(b \cdot d) \cdot (fs_1/fc) = 0.025712$

$2 = Asl,com/(b \cdot d) \cdot (fs_2/fc) = 0.07012363$

$v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.06389042$

and confined core properties:

$b = 690.00$

$d = 477.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

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

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

$1 = Asl,ten/(b \cdot d) \cdot (fs_1/fc) = 0.02970555$

$2 = Asl,com/(b \cdot d) \cdot (fs_2/fc) = 0.08101513$

$v = Asl,mid/(b \cdot d) \cdot (fsv/fc) = 0.07381378$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$su (4.9) = 0.15509944$

$Mu = MRc (4.14) = 2.9288E+008$

$u = su (4.1) = 1.1952435E-005$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of Shear Strength $Vr = \text{Min}(Vr_1, Vr_2) = 452028.293$

Calculation of Shear Strength at edge 1, $Vr_1 = 452028.293$

$Vr_1 = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$

$V_{Col0} = 452028.293$

$knl = 1$ (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)

$fc' = 33.00$, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$Mu = 645.4488$

$Vu = 0.00014703$

$d = 0.8 \cdot h = 440.00$

$Nu = 9867.326$

$Ag = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$d = 440.00$

$Av = 157079.633$

$fy = 555.56$

$s = 150.00$

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

$s/d = 0.34090909$

$V_{s2} = 116356.214$ is calculated for section flange, with:

$d = 200.00$

$Av = 157079.633$

$fy = 555.56$

$s = 150.00$

V_{s2} 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 <= 419774.846
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 452028.293
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 452028.293
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' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 645.4488
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 = 372339.886

where:

Vs1 = 255983.671 is calculated for section web, with:

d = 440.00
Av = 157079.633
fy = 555.56
s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 116356.214 is calculated for section flange, with:

d = 200.00
Av = 157079.633
fy = 555.56
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 <= 419774.846

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 = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

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 = 694.45

#####

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 = 1.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 3.6540709E-008$
EDGE -B-
Shear Force, $V_b = -3.6540709E-008$
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: $A_{st,ten} = 1231.504$
-Compression: $A_{st,com} = 1231.504$
-Middle: $A_{st,mid} = 2689.203$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.56523739$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$
with
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 5.7828E+008$
 $\mu_{1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{1-} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 5.7828E+008$
 $\mu_{2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{2-} = 5.7828E+008$, 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_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 9.2773974E-006$
 $M_u = 5.7828E+008$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$
 $N = 9867.326$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o / l_{ou,min} = l_b / l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o / l_{ou,min} = l_b / l_{b,min} = 0.30$$

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

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

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

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

with $f_{s2} = f_s = 389.0139$
 with $E_{s2} = E_s = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 466.8167$
 $fy_v = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 389.0139$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.0821349$
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.0821349$
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.17935581$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.11286126$
 $2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.11286126$
 $v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.24645214$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21940748$
 $Mu = MRc (4.14) = 5.7828E+008$
 $u = su (4.1) = 9.2773974E-006$

 Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_1 -

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

$u = 9.2773974E-006$
 $Mu = 5.7828E+008$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$

$$w_e (5.4c) = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$f_{yv} = 389.0139$$

$$s_{uv} = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

For calculation of $e_{suv,nominal}$ and γ_v , γ_{sh} , γ_{ftv} , γ_{fyv} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{sv} = f_s = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.0821349$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

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

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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

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

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

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_o/l_{ou,min} = l_b/l_d = 0.30$

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$$l_0/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

For calculation of $e_{suv,nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.0821349$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2}

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

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00631023$$

$$\text{we (5.4c) } = 0.00493587$$

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

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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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).

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

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

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

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

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 389.0139$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0821349$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0821349$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11286126$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11286126$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.21940748

$M_u = M_{Rc}$ (4.14) = 5.7828E+008

$u = \mu_u$ (4.1) = 9.2773974E-006

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 682046.925$

Calculation of Shear Strength at edge 1, $V_{r1} = 682046.925$

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

$V_{Col0} = 682046.925$

$k_{nl} = 1$ (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)

$f_c' = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.36802142$

$V_u = 3.6540709E-008$

$d = 0.8 \cdot h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 0.75$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

V_{s2} 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 <= 572420.244
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 682046.925
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 682046.925
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' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.36791177
Vu = 3.6540709E-008
d = 0.8*h = 600.00
Nu = 9867.326
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 465424.857
where:
Vs1 = 116356.214 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 555.56
s = 150.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.75
Vs2 = 349068.643 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 555.56
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 <= 572420.244
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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 250.00
Max Width, Wmax = 750.00

Min Width, $W_{min} = 250.00$
Eccentricity, $Ecc = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -204296.466$
Shear Force, $V_2 = -2785.183$
Shear Force, $V_3 = 104.8793$
Axial Force, $F = -10296.313$
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, $DbL = 17.77778$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^*$ $u = 0.00549875$
 $u = y + p = 0.00549875$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00549875$ ((4.29), Biskinis Phd)
 $M_y = 3.8347E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1947.92
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$
factor = 0.30
 $A_g = 262500.00$
 $f_c' = 33.00$
 $N = 10296.313$
 $E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 5.1438344E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 311.2112$
 $d = 507.00$
 $y = 0.40333547$
 $A = 0.04090964$
 $B = 0.02748095$
with $pt = 0.01784573$
 $pc = 0.00654344$
 $pv = 0.01625945$
 $N = 10296.313$
 $b = 250.00$
 $" = 0.08481262$
 $y_{comp} = 1.0781542E-005$

with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.40247858$
 $A = 0.040464$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

- Calculation of ρ -

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

with:

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

shear control ratio $V_y E / V_{CoI} E = 0.88728525$

$d = 507.00$

$s = 0.00$

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

$A_v = 78.53982$, 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.

$NUD = 10296.313$

$A_g = 262500.00$

$f_{cE} = 33.00$

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

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

$b = 250.00$

$d = 507.00$

$f_{cE} = 33.00$

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

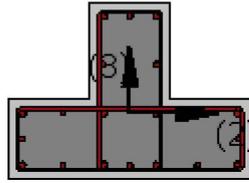
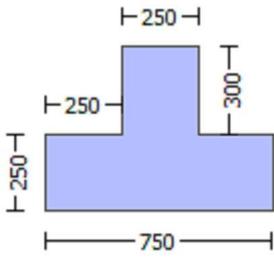
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -204296.466$

Shear Force, $V_a = 104.8793$

EDGE -B-

Bending Moment, $M_b = -109989.728$

Shear Force, $V_b = -104.8793$

BOTH EDGES

Axial Force, $F = -10296.313$

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: $A_{sl,ten} = 2261.947$
-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 $V_R = 1.0 \cdot V_n = 404631.557$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 404631.557$

$V_{CoI} = 404631.557$

$k_n = 1.00$

$displacement_ductility_demand = 0.00160399$

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)

$M/Vd = 4.00$

$M_u = 204296.466$

$V_u = 104.8793$

$d = 0.8 \cdot h = 440.00$

$N_u = 10296.313$

$A_g = 137500.00$

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 $\theta = 8.8199641E-006$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00549875$ ((4.29), Biskinis Phd)

$M_y = 3.8347E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1947.92

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 4.5281E+013$

$factor = 0.30$

$A_g = 262500.00$

$f_c' = 33.00$

$N = 10296.313$

$E_c \cdot I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 5.1438344\text{E-}006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 311.2112$
 $d = 507.00$
 $y = 0.40333547$
 $A = 0.04090964$
 $B = 0.02748095$
with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10296.313$
 $b = 250.00$
 $" = 0.08481262$
 $y_{\text{comp}} = 1.0781542\text{E-}005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.40247858$
 $A = 0.040464$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

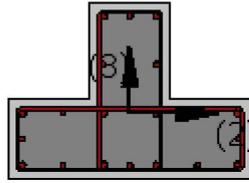
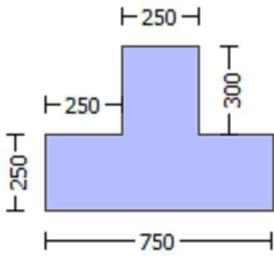
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

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, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 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 = 1.00
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 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 , $V_e/V_r = 0.88728525$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 6.0162E+008$

$M_{u1+} = 6.0162E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.9288E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 6.0162E+008$

$M_{u2+} = 6.0162E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.9288E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 1.5713663E-005$

$M_u = 6.0162E+008$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00235905$

$N = 9867.326$

$f_c = 33.00$

α_1 (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00631023$

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

From (5.4b), TBDY: $\phi_{cu} = 0.00631023$

ϕ_{we} (5.4c) = 0.00493587

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

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).

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

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

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

$\phi_{sh,y}$ ((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

$s = 150.00$

$$fywe = 694.45$$

$$fce = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

$$lo/lou,min = lb/d = 0.30$$

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

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

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

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

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

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

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

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

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

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/d = 0.30$$

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.21037088$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07713599$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.29421283$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.10787804$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.26806058$$

Case/Assumption: Unconfinedsd 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

---->

$$s_u(4.8) = 0.35733511$$

$$\mu_u = M_{Rc}(4.15) = 6.0162E+008$$

$$u = s_u(4.1) = 1.5713663E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$$u = 1.1952435E-005$$

$$\mu_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00631023$$

$$\mu_{ue}(5.4c) = 0.00493587$$

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

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 $b_i^2/6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

$c = \text{confinement factor} = 1.00$
 $y1 = 0.00140044$
 $sh1 = 0.0044814$
 $ft1 = 466.8167$
 $fy1 = 389.0139$
 $su1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $su1 = 0.4 * esu1_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs1 = fs = 389.0139$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00140044$
 $sh2 = 0.0044814$
 $ft2 = 466.8167$
 $fy2 = 389.0139$
 $su2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/lb,min = 0.30$
 $su2 = 0.4 * esu2_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs2 = fs = 389.0139$
 with $Es2 = Es = 200000.00$
 $yv = 0.00140044$
 $shv = 0.0044814$
 $ftv = 466.8167$
 $fyv = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4 * esuv_nominal ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 389.0139$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.025712$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.07012363$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.06389042$
 and confined core properties:
 $b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $fcc (5A.2, \text{TBDY}) = 33.00$
 $cc (5A.5, \text{TBDY}) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.02970555$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.08101513$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.07381378$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.15509944
Mu = MRc (4.14) = 2.9288E+008
u = su (4.1) = 1.1952435E-005

Calculation of ratio lb/l_d

Inadequate Lap Length with lb/l_d = 0.30

Calculation of Mu₂₊

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

u = 1.5713663E-005
Mu = 6.0162E+008

with full section properties:

b = 250.00
d = 507.00
d' = 43.00
v = 0.00235905
N = 9867.326
f_c = 33.00
c_o (5A.5, TBDY) = 0.002

Final value of c_u: c_u* = shear_factor * Max(c_u, c_c) = 0.00631023
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: c_u = 0.00631023

w_e (5.4c) = 0.00493587
a_{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_i²/6 as defined at (A.2).
p_{sh,min} = Min(p_{sh,x}, p_{sh,y}) = 0.00271274
Expression ((5.4d), TBDY) for p_{sh,min} has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

p_{sh,x} ((5.4d), 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} = 694.45
f_{ce} = 33.00
From ((5.A5), TBDY), TBDY: c_c = 0.002
c = confinement factor = 1.00
y₁ = 0.00140044
sh₁ = 0.0044814
ft₁ = 466.8167
fy₁ = 389.0139

```

su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 0.30
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 = 389.0139
with Es1 = Es = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 389.0139
with Es2 = Es = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 466.8167
fyv = 389.0139
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 0.30
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 = 389.0139
with Esv = Es = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.21037088
2 = Asl,com/(b*d)*(fs2/fc) = 0.07713599
v = Asl,mid/(b*d)*(fsv/fc) = 0.19167125
and confined core properties:
b = 190.00
d = 477.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.29421283
2 = Asl,com/(b*d)*(fs2/fc) = 0.10787804
v = Asl,mid/(b*d)*(fsv/fc) = 0.26806058
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) = 0.35733511
Mu = MRc (4.15) = 6.0162E+008

```

$$u = s_u(4.1) = 1.5713663E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of μ_2

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

$$u = 1.1952435E-005$$

$$\mu = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TB DY: } \mu = 0.00631023$$

$$w_e(5.4c) = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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

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

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

y2, sh2,ft2,fy2, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.025712

2 = Asl,com/(b*d)*(fs2/fc) = 0.07012363

v = Asl,mid/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

b = 690.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02970555

2 = Asl,com/(b*d)*(fs2/fc) = 0.08101513

v = Asl,mid/(b*d)*(fsv/fc) = 0.07381378

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vsy2 - LHS eq.(4.5) is satisfied

su (4.9) = 0.15509944

Mu = MRc (4.14) = 2.9288E+008

u = su (4.1) = 1.1952435E-005

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 452028.293$

Calculation of Shear Strength at edge 1, $V_{r1} = 452028.293$

$V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = knl * V_{Co1O}$

$V_{Co1O} = 452028.293$

$knl = 1$ (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)

$f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 645.4488$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 0.34090909$

$V_{s2} = 116356.214$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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: $V_s + V_f \leq 419774.846$

$bw = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 452028.293$

$V_{r2} = V_{Co2} ((10.3), ASCE 41-17) = knl * V_{Co2O}$

$V_{Co2O} = 452028.293$

$knl = 1$ (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)

$f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 645.4488$

$V_u = 0.00014703$

$d = 0.8 * h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

Vs1 is multiplied by Col1 = 1.00
s/d = 0.34090909
Vs2 = 116356.214 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 555.56
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 <= 419774.846
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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45

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 = 1.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with lo/lo,min = 0.30
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 3.6540709E-008
EDGE -B-
Shear Force, Vb = -3.6540709E-008
BOTH EDGES
Axial Force, F = -9867.326
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00

-Compression: $As_{lc} = 5152.212$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{l,ten} = 1231.504$
-Compression: $As_{l,com} = 1231.504$
-Middle: $As_{l,mid} = 2689.203$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.56523739$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$
with

$M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 5.7828E+008$
 $Mu_{1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 5.7828E+008$
 $Mu_{2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $Mu_{2-} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 9.2773974E-006$
 $Mu = 5.7828E+008$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$
 $N = 9867.326$
 $f_c = 33.00$
 ϕ_c (5A.5, TBDY) = 0.002
Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.00631023$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_c = 0.00631023$
 ϕ_w (5.4c) = 0.00493587
 $\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$
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).
 $\phi_{psh,min} = \text{Min}(\phi_{psh,x} , \phi_{psh,y}) = 0.00271274$
Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/lb = 0.30

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

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

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

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

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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

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

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

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

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/lb = 0.30

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

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

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

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

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

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

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{s1,com}/(b*d)*(f_{s2}/f_c) = 0.11286126$$

$$v = A_{s1,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

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

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

$$\text{su (4.9)} = 0.21940748$$

$$\text{Mu} = \text{MRc (4.14)} = 5.7828\text{E}+008$$

$$u = \text{su (4.1)} = 9.2773974\text{E}-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_1 -

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

$$u = 9.2773974\text{E}-006$$

$$\text{Mu} = 5.7828\text{E}+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.00631023$

$$w_e \text{ (5.4c)} = 0.00493587$$

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

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

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

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

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

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

$$lo/lou,min = lb/ld = 0.30$$

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

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.

$$\text{with } fs1 = fs = 389.0139$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

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

$$lo/lou,min = lb/lb,min = 0.30$$

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

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.

$$\text{with } fs2 = fs = 389.0139$$

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

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$$lo/lou,min = lb/ld = 0.30$$

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

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.

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.0821349$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.0821349$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

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

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.11286126$$

$$2 = Asl,com / (b * d) * (fs2 / fc) = 0.11286126$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.24645214$$

Case/Assumption: Unconfinedsd full section - Steel rupture

satisfies Eq. (4.3)

--->

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

--->

$$s_u(4.9) = 0.21940748$$

$$M_u = M_{Rc}(4.14) = 5.7828E+008$$

$$u = s_u(4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

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

$$\phi_u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.00631023$$

$$\phi_{ue}(5.4c) = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$sh1 = 0.0044814$
 $ft1 = 466.8167$
 $fy1 = 389.0139$
 $su1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/ld = 0.30$
 $su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$
 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 $fs1 = fs = 389.0139$
 with $Es1 = Es = 200000.00$
 $y2 = 0.00140044$
 $sh2 = 0.0044814$
 $ft2 = 466.8167$
 $fy2 = 389.0139$
 $su2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 0.30$
 $su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$
 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 $fs2 = fs = 389.0139$
 with $Es2 = Es = 200000.00$
 $yv = 0.00140044$
 $shv = 0.0044814$
 $ftv = 466.8167$
 $fyv = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/ld = 0.30$
 $suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = fs = 389.0139$
 with $Esv = Es = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.11286126$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.24645214$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21940748$

$$\begin{aligned} \text{Mu} &= \text{MRc} (4.14) = 5.7828\text{E}+008 \\ u &= \text{su} (4.1) = 9.2773974\text{E}-006 \end{aligned}$$

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

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

$$\begin{aligned} u &= 9.2773974\text{E}-006 \\ \text{Mu} &= 5.7828\text{E}+008 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 250.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00169171 \\ N &= 9867.326 \\ f_c &= 33.00 \end{aligned}$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

2 = Asl,com/(b*d)*(fs2/fc) = 0.11286126

v = Asl,mid/(b*d)*(fsv/fc) = 0.24645214

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.21940748

Mu = MRc (4.14) = 5.7828E+008

u = su (4.1) = 9.2773974E-006

Calculation of ratio lb/d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 682046.925$

Calculation of Shear Strength at edge 1, $V_{r1} = 682046.925$

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

$V_{Co10} = 682046.925$

$knl = 1$ (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)

$fc' = 33.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu = 0.36802142$

$V_u = 3.6540709E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 0.75$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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: $V_s + V_f \leq 572420.244$

$b_w = 250.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 682046.925$

$V_{r2} = V_{Co2} ((10.3), ASCE 41-17) = knl * V_{Co10}$

$V_{Co10} = 682046.925$

$knl = 1$ (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)

$fc' = 33.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu = 0.36791177$

$V_u = 3.6540709E-008$

$d = 0.8 * h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.75

Vs2 = 349068.643 is calculated for section flange, with:

d = 600.00

Av = 157079.633

fy = 555.56

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 <= 572420.244

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -8.5117E+006$

Shear Force, $V_2 = -2785.183$

Shear Force, $V_3 = 104.8793$

Axial Force, $F = -10296.313$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl} = 0.00$

-Compression: $A_{slc} = 5152.212$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

Mean Diameter of Tension Reinforcement, $DbL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^* u = 0.00539449$
 $u = y + p = 0.00539449$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00539449$ ((4.29), Biskinis Phd))
 $M_y = 3.9374E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3056.073
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.4354E+013$
factor = 0.30
Ag = 262500.00
fc' = 33.00
N = 10296.313
 $E_c * I_g = 2.4785E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1941313E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$
d = 707.00
 $y = 0.31094644$
A = 0.0293369
B = 0.01564849
with $p_t = 0.00696749$
pc = 0.00696749
pv = 0.01521473
N = 10296.313
b = 250.00
" = 0.06082037
 $y_{comp} = 1.0047538E-005$
with fc = 33.00
Ec = 26999.444
 $y = 0.30970808$
A = 0.02901732
B = 0.01546131
with Es = 200000.00

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

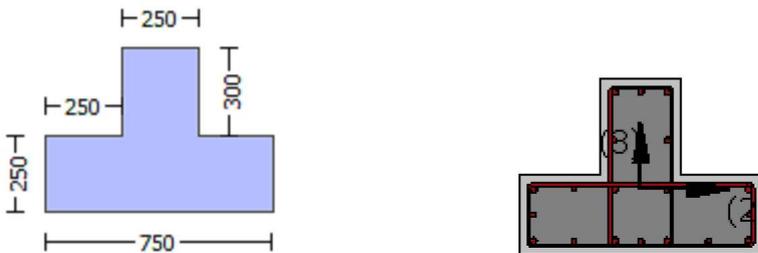
- Columns not controlled by inadequate development or splicing along the clear height because $I_b / I_d \geq 1$
shear control ratio $V_y E / V_{Col} O E = 0.56523739$
d = 707.00
s = 0.00
 $t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = A_v * L_{stir} / (A_g * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$
Av = 78.53982, is the area of every stirrup
Lstir = 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 = 10296.313
Ag = 262500.00
fcE = 33.00
fytE = fyIE = 0.00
pl = Area_Tot_Long_Rein/(b*d) = 0.02914971
b = 250.00
d = 707.00
fcE = 33.00

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 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, = 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, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -8.5117E+006$

Shear Force, $V_a = -2785.183$

EDGE -B-

Bending Moment, $M_b = 154158.603$

Shear Force, $V_b = 2785.183$

BOTH EDGES

Axial Force, $F = -10296.313$

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 $V_R = 1.0 * V_n = 607762.51$

V_n ((10.3), ASCE 41-17) = $k_n * V_{CoI0} = 607762.51$

$V_{CoI} = 607762.51$

$k_n = 1.00$

$displacement_ductility_demand = 0.03351779$

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)

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

$M/Vd = 2.00$

$M_u = 154158.603$

$V_u = 2785.183$

$d = 0.8 * h = 600.00$

$N_u = 10296.313$

$A_g = 187500.00$

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
Av = 157079.633
fy = 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
Av = 157079.633
fy = 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
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 = 1.7749381E-005
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00052955$ ((4.29), Biskinis Phd)
My = 3.9374E+008
Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 7.4354E+013$
factor = 0.30
Ag = 262500.00
fc' = 33.00
N = 10296.313
 $E_c \cdot I_g = 2.4785E+014$

Calculation of Yielding Moment My

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

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1941313E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 311.2112$
d = 707.00
y = 0.31094644
A = 0.0293369
B = 0.01564849
with pt = 0.00696749
pc = 0.00696749
pv = 0.01521473
N = 10296.313
b = 250.00
" = 0.06082037
 $y_{comp} = 1.0047538E-005$
with fc = 33.00
Ec = 26999.444
y = 0.30970808
A = 0.02901732
B = 0.01546131
with Es = 200000.00

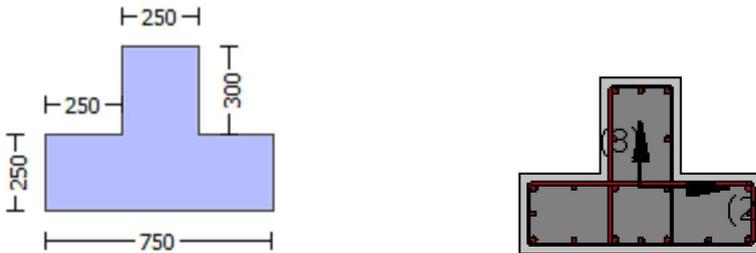
Calculation of ratio Ib/I_d

Inadequate Lap Length with Ib/I_d = 0.30

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 (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, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 * f_{sm} = 694.45$
 #####
 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 = 1.00
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{o,min} = 0.30$
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: $As_{c,com} = 829.3805$
-Middle: $As_{mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.88728525$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 6.0162E+008$
 $Mu_{1+} = 6.0162E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 2.9288E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 6.0162E+008$
 $Mu_{2+} = 6.0162E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{2-} = 2.9288E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 1.5713663E-005$
 $Mu = 6.0162E+008$

with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00235905$
 $N = 9867.326$
 $f_c = 33.00$
 $\omega (5A.5, TBDY) = 0.002$
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.00631023$

w_e (5.4c) = 0.00493587

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

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).

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

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

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

$s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

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

$$lo/lo_{u,min} = lb/ld = 0.30$$

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

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.

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.21037088$$

$$2 = Asl_{com}/(b*d) * (fs2/fc) = 0.07713599$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

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

$$1 = Asl_{ten}/(b*d) * (fs1/fc) = 0.29421283$$

$$2 = Asl_{com}/(b*d) * (fs2/fc) = 0.10787804$$

$$v = Asl_{mid}/(b*d) * (fsv/fc) = 0.26806058$$

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

$$su (4.8) = 0.35733511$$

$$Mu = MRc (4.15) = 6.0162E+008$$

$$u = su (4.1) = 1.5713663E-005$$

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of $Mu1$ -

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

$$u = 1.1952435E-005$$

$$Mu = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, co) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } cu = 0.00631023$$

$$we (5.4c) = 0.00493587$$

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

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).

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

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

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

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$lo/lou,min = lb/d = 0.30$

$su_1 = 0.4 * esu1_nominal$ ((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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$lo/lou,min = lb/lb,min = 0.30$

$su_2 = 0.4 * esu2_nominal$ ((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 $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$l_o/l_{o,min} = l_b/d = 0.30$

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

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

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

For calculation of $e_{suv,nominal}$ and γ_v , sh_v, ft_v, f_{y_v} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1, ft_1, f_{y_1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 389.0139$

with $E_{sv} = E_s = 200000.00$

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.025712$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07012363$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.06389042$

and confined core properties:

$b = 690.00$

$d = 477.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

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

$c =$ confinement factor = 1.00

$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.02970555$

$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.08101513$

$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.07381378$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$su (4.9) = 0.15509944$

$Mu = MRc (4.14) = 2.9288E+008$

$u = su (4.1) = 1.1952435E-005$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of Mu_{2+}

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

$u = 1.5713663E-005$

$Mu = 6.0162E+008$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00235905$

$N = 9867.326$

$f_c = 33.00$

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

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

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

From (5.4b), TBDY: $cu = 0.00631023$

$w_e (5.4c) = 0.00493587$

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

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

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

psh,x ((5.4d), 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
 considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv_nominal}$ and γ_v , sh_v, ft_v, f_{y_v} , it is considered
 characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 γ_1 , sh_1, ft_1, f_{y_1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $f_{sv} = f_s = 389.0139$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.21037088$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07713599$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.19167125$

and confined core properties:

$b = 190.00$
 $d = 477.00$
 $d' = 13.00$
 f_{cc} (5A.2, TBDY) = 33.00
 cc (5A.5, TBDY) = 0.002
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.29421283$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.10787804$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.26806058$

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) = 0.35733511
 $Mu = MRc$ (4.15) = 6.0162E+008
 $u = su$ (4.1) = 1.5713663E-005

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_2 -

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

$u = 1.1952435E-005$
 $Mu = 2.9288E+008$

with full section properties:

$b = 750.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00078635$
 $N = 9867.326$
 $f_c = 33.00$
 cc (5A.5, TBDY) = 0.002

Final value of cu^* = $\text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$

w_e (5.4c) = 0.00493587

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

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).

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

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

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

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

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 389.0139$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.025712$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07012363$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.06389042$

and confined core properties:

$b = 690.00$

$d = 477.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.02970555$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08101513$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07381378$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.15509944

$M_u = M_{Rc}$ (4.14) = 2.9288E+008

$u = \mu_u$ (4.1) = 1.1952435E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 452028.293$

Calculation of Shear Strength at edge 1, $V_{r1} = 452028.293$

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

$V_{Col0} = 452028.293$

$k_{nl} = 1$ (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)

$f_c' = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 645.4488$

$V_u = 0.00014703$

$d = 0.8 \cdot h = 440.00$

$N_u = 9867.326$

$A_g = 137500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$d = 440.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 0.34090909$

$V_{s2} = 116356.214$ is calculated for section flange, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

V_{s2} 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 <= 419774.846
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 452028.293
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 452028.293
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' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 645.4488
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 = 372339.886
where:
Vs1 = 255983.671 is calculated for section web, with:
d = 440.00
Av = 157079.633
fy = 555.56
s = 150.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.34090909
Vs2 = 116356.214 is calculated for section flange, with:
d = 200.00
Av = 157079.633
fy = 555.56
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 <= 419774.846
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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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 = 694.45

#####

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 = 1.00
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 3.6540709E-008$
EDGE -B-
Shear Force, $V_b = -3.6540709E-008$
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: $A_{st,ten} = 1231.504$
-Compression: $A_{st,com} = 1231.504$
-Middle: $A_{st,mid} = 2689.203$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.56523739$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$
with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 5.7828E+008$
 $M_{u1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 5.7828E+008$, 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
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 5.7828E+008$
 $M_{u2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $M_{u2-} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 9.2773974E-006$
 $M_u = 5.7828E+008$

with full section properties:
 $b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

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

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

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

y_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 $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$suv = 0.00512$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

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

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fs_{yv} = f_{sv}/1.2$, 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 $f_{sv} = fs = 389.0139$

with $Es_v = Es = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0821349$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0821349$

v = $Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17935581$

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

f_{cc} (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11286126$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11286126$

v = $Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.21940748

Mu = MRc (4.14) = 5.7828E+008

u = su (4.1) = 9.2773974E-006

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu1-

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

u = 9.2773974E-006

Mu = 5.7828E+008

with full section properties:

b = 250.00

d = 707.00

d' = 43.00

v = 0.00169171

N = 9867.326

f_c = 33.00

cc (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \text{Max}(\phi_u, cc) = 0.00631023$

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

From (5.4b), TBDY: $c_u = 0.00631023$

w_e (5.4c) = 0.00493587

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

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).

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

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

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

$s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

c = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$$f_{tv} = 466.8167$$

$$f_{yv} = 389.0139$$

$$s_{uv} = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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

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

For calculation of $e_{suv,nominal}$ and γ_v , sh_v, f_{tv}, f_{yv} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1, f_{t1}, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.0821349$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

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

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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).

$psh_{min} = \text{Min}(psh_x, psh_y) = 0.00271274$

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

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

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

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$lo/lou_{min} = lb/ld = 0.30$

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$lo/lou_{min} = lb/lb_{min} = 0.30$

$su_2 = 0.4 * esu_{2_nominal} \text{ ((5.5), TBDY)} = 0.032$

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

2 = Asl,com/(b*d)*(fs2/fc) = 0.11286126

v = Asl,mid/(b*d)*(fsv/fc) = 0.24645214

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

su (4.9) = 0.21940748

Mu = MRc (4.14) = 5.7828E+008

u = su (4.1) = 9.2773974E-006

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Mu2-

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

u = 9.2773974E-006

Mu = 5.7828E+008

with full section properties:

b = 250.00

d = 707.00

d' = 43.00

v = 0.00169171

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.00631023

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

From (5.4b), TBDY: cu = 0.00631023

we (5.4c) = 0.00493587

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_{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.

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

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

psh,x ((5.4d), 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

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

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

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

For calculation of $e_{sv_nominal}$ and γ_v , sh_v , ft_v , fy_v , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $f_{sv} = f_s = 389.0139$

with $E_{sv} = E_s = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0821349$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0821349$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $Asl_{ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11286126$

2 = $Asl_{com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11286126$

$v = Asl_{mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

μ_u (4.9) = 0.21940748

$M_u = MR_c$ (4.14) = 5.7828E+008

$u = \mu_u$ (4.1) = 9.2773974E-006

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 682046.925$

Calculation of Shear Strength at edge 1, $V_{r1} = 682046.925$

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

$V_{Col0} = 682046.925$

$k_{nl} = 1$ (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)

$f_c' = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.36802142$

$V_u = 3.6540709E-008$

$d = 0.8 \cdot h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 0.75$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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 <= 572420.244
bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 682046.925
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 682046.925
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' = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 0.36791177
Vu = 3.6540709E-008
d = 0.8*h = 600.00
Nu = 9867.326
Ag = 187500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 465424.857
where:

Vs1 = 116356.214 is calculated for section web, with:
d = 200.00
Av = 157079.633
fy = 555.56
s = 150.00

Vs1 is multiplied by Col1 = 1.00
s/d = 0.75

Vs2 = 349068.643 is calculated for section flange, with:
d = 600.00
Av = 157079.633
fy = 555.56
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 <= 572420.244
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, = 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 = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Max Height, Hmax = 550.00
Min Height, Hmin = 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
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_b/l_d = 0.30$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -109989.728$
Shear Force, $V_2 = 2785.183$
Shear Force, $V_3 = -104.8793$
Axial Force, $F = -10296.313$
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 $u,R = 1.0^*$ $u = 0.00296043$
 $u = y + p = 0.00296043$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00296043$ ((4.29), Biskinis Phd)
 $M_y = 3.8347E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1048.727
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$
factor = 0.30
 $A_g = 262500.00$
 $f_c' = 33.00$
 $N = 10296.313$
 $E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 5.1438344E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 311.2112$
 $d = 507.00$
 $y = 0.40333547$
 $A = 0.04090964$
 $B = 0.02748095$
with $pt = 0.01784573$
 $pc = 0.00654344$
 $pv = 0.01625945$
 $N = 10296.313$
 $b = 250.00$
 $" = 0.08481262$

y_comp = 1.0781542E-005
with fc = 33.00
Ec = 26999.444
y = 0.40247858
A = 0.040464
B = 0.02721993
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of ρ -

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

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/ld ≥ 1

shear control ratio $V_y E / V_{CoI} E = 0.88728525$

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 = 10296.313

$A_g = 262500.00$

$f_{cE} = 33.00$

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

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

b = 250.00

d = 507.00

$f_{cE} = 33.00$

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

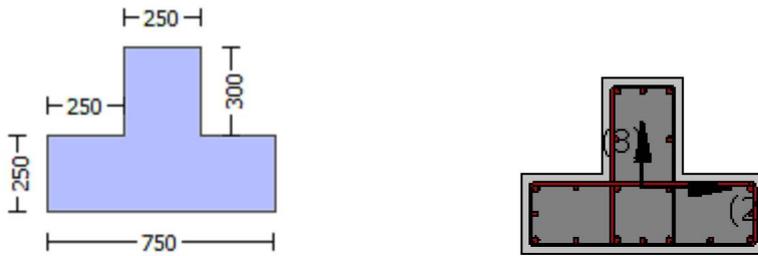
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -204296.466$
 Shear Force, $V_a = 104.8793$
 EDGE -B-
 Bending Moment, $M_b = -109989.728$
 Shear Force, $V_b = -104.8793$
 BOTH EDGES
 Axial Force, $F = -10296.313$
 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, $D_{bL,ten} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 451787.437$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 451787.437$
 $V_{CoI} = 451787.437$
 $k_n = 1.00$
 $displacement_ductility_demand = 5.1912520E-006$

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)
 $f'_c = 25.00$, but $f_c^{0.5} \leq 8.3$ MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.38347$
 $M_u = 109989.728$
 $V_u = 104.8793$
 $d = 0.8 \cdot h = 440.00$
 $N_u = 10296.313$
 $A_g = 137500.00$
 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 $\phi = 1.5368352E-008$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00296043$ ((4.29), Biskinis Phd)

$M_y = 3.8347E+008$
 $L_s = M/V$ (with $L_s > 0.1*L$ and $L_s < 2*L$) = 1048.727
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$
factor = 0.30
Ag = 262500.00
fc' = 33.00
N = 10296.313
 $E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 5.1438344E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 311.2112$
d = 507.00
y = 0.40333547
A = 0.04090964
B = 0.02748095
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10296.313
b = 250.00
" = 0.08481262
 $y_{comp} = 1.0781542E-005$
with fc = 33.00
Ec = 26999.444
y = 0.40247858
A = 0.040464
B = 0.02721993
with Es = 200000.00

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

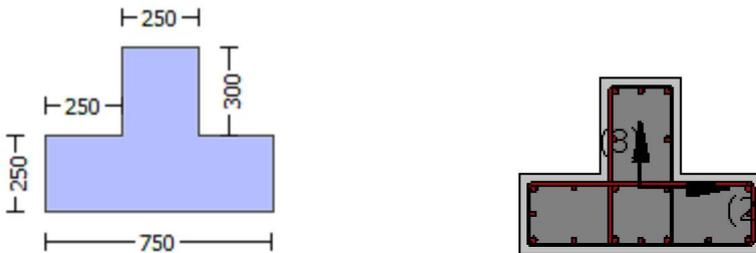
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

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 = 1.00

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = 0.30$

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: $A_{s,ten} = 2261.947$

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

-Middle: $A_{s,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.88728525$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 6.0162E+008$

$M_{u1+} = 6.0162E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.9288E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 6.0162E+008$

$M_{u2+} = 6.0162E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 2.9288E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 1.5713663E-005$

$M_u = 6.0162E+008$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00235905$

$N = 9867.326$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$

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

From (5.4b), TBDY: $\phi_u = 0.00631023$

$\phi_{c1} = 0.00493587$

$\phi_{c2} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

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).

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

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

earthquake detailing (90° closed stirrups)

$$\text{psh}_x \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00271274$$

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

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

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

$$\text{psh}_y \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00351061$$

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.21037088$$

$$2 = A_{sl,com}/(b*d)^*(f_{s2}/f_c) = 0.07713599$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d)^*(f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d)^*(f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.26806058$$

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

--->

$$s_u (4.8) = 0.35733511$$

$$M_u = M_{Rc} (4.15) = 6.0162E+008$$

$$u = s_u (4.1) = 1.5713663E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_u1 -

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

$$u = 1.1952435E-005$$

$$M_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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).

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

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

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

Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = 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 = 694.45
fce = 33.00

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

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

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 = 389.0139
with Es1 = Es = 200000.00

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139
with Es2 = Es = 200000.00

yv = 0.00140044
shv = 0.0044814
ftv = 466.8167
fyv = 389.0139
suv = 0.00512

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

lo/lou,min = lb/d = 0.30

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 = 389.0139
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.025712
2 = Asl,com/(b*d)*(fs2/fc) = 0.07012363
v = Asl,mid/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

$b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.02970555$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08101513$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07381378$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.15509944$
 $Mu = MRc (4.14) = 2.9288E+008$
 $u = su (4.1) = 1.1952435E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_{2+}

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

$u = 1.5713663E-005$
 $Mu = 6.0162E+008$

 with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00235905$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$
 $w_e (5.4c) = 0.00493587$

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

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).

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

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

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

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

Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.21037088

2 = Asl,com/(b*d)*(fs2/fc) = 0.07713599

v = Asl,mid/(b*d)*(fsv/fc) = 0.19167125

and confined core properties:

b = 190.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29421283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10787804$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.26806058$

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

--->
 $s_u(4.8) = 0.35733511$
 $\mu_u = MR_c(4.15) = 6.0162E+008$
 $u = s_u(4.1) = 1.5713663E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of μ_u

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

$u = 1.1952435E-005$
 $\mu_u = 2.9288E+008$

 with full section properties:

$b = 750.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00078635$
 $N = 9867.326$
 $f_c = 33.00$
 $\alpha(5A.5, TBDY) = 0.002$

Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.00631023$

$\alpha_{we}(5.4c) = 0.00493587$
 $\alpha_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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 $b^2/6$ as defined at (A.2).

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

Expression ((5.4d), TBDY) for $\alpha_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

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

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

$s = 150.00$
 $fy_{we} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 466.8167$
 $fy_1 = 389.0139$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 389.0139$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 466.8167$
 $fy_2 = 389.0139$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 389.0139$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 466.8167$
 $fy_v = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 389.0139$
 with $Es_v = Es = 200000.00$
 $1 = Asl, \text{ten}/(b*d) * (fs_1/fc) = 0.025712$
 $2 = Asl, \text{com}/(b*d) * (fs_2/fc) = 0.07012363$
 $v = Asl, \text{mid}/(b*d) * (fsv/fc) = 0.06389042$
 and confined core properties:
 $b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten}/(b*d) * (fs_1/fc) = 0.02970555$
 $2 = Asl, \text{com}/(b*d) * (fs_2/fc) = 0.08101513$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07381378$$

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

--->

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

--->

$$s_u(4.9) = 0.15509944$$

$$M_u = M_{Rc}(4.14) = 2.9288E+008$$

$$u = s_u(4.1) = 1.1952435E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 452028.293$

Calculation of Shear Strength at edge 1, $V_{r1} = 452028.293$

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

$$V_{Col0} = 452028.293$$

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

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

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

$$f_c' = 33.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 4.00$$

$$M_u = 645.4488$$

$$V_u = 0.00014703$$

$$d = 0.8 \cdot h = 440.00$$

$$N_u = 9867.326$$

$$A_g = 137500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 372339.886$$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$$d = 440.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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

$$s/d = 0.34090909$$

$V_{s2} = 116356.214$ is calculated for section flange, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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

$$s/d = 0.75$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 419774.846$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 452028.293$

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

$$V_{Col0} = 452028.293$$

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

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

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

$$f_c' = 33.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$M/Vd = 4.00$
 $\mu_u = 645.4488$
 $V_u = 0.00014703$
 $d = 0.8 \cdot h = 440.00$
 $N_u = 9867.326$
 $A_g = 137500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$
 where:
 $V_{s1} = 255983.671$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 116356.214$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 150.00$
 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: $V_s + V_f \leq 419774.846$
 $b_w = 250.00$

 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, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 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 = 1.00
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6540709E-008$

EDGE -B-

Shear Force, $V_b = -3.6540709E-008$

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, $V_e/V_r = 0.56523739$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.7828E+008$

$Mu_{1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.7828E+008$

$Mu_{2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 9.2773974E-006$

$M_u = 5.7828E+008$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00169171$

$N = 9867.326$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$

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

From (5.4b), TBDY: $\phi_u = 0.00631023$

$\omega_e (5.4c) = 0.00493587$

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

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).

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

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

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

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

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

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

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

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

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

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

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

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

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

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

$l_o/l_{o,min} = l_b/l_d = 0.30$

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

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

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

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 389.0139$

with $E_{sv} = E_s = 200000.00$

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0821349$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0821349$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

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

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

1 = $A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11286126$

2 = $A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11286126$

$v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$\mu_u (4.9) = 0.21940748$

$M_u = M_{Rc} (4.14) = 5.7828E+008$

$u = \mu_u (4.1) = 9.2773974E-006$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u1} -

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

$u = 9.2773974E-006$

$M_u = 5.7828E+008$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00169171$

$N = 9867.326$

$f_c = 33.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.00631023$

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

From (5.4b), TBDY: $\mu_u = 0.00631023$

$w_e (5.4c) = 0.00493587$

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

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).

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

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

earthquake detailing (90° closed stirrups)

$$\text{psh}_x \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00271274$$

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

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

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

$$\text{psh}_y \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00351061$$

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

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

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

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

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

$$\text{with } fs_2 = fs = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$su_v = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

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

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

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

$$\text{with } fsv = fs = 389.0139$$

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

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.0821349$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

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

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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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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).

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

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

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

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

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

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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = MR_c (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_u2 -

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

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

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

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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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).

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

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

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

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

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

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

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

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

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

Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.21940748$$

$$M_u = M_{Rc}(4.14) = 5.7828E+008$$

$$u = s_u(4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 682046.925$

Calculation of Shear Strength at edge 1, $V_{r1} = 682046.925$

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

$$V_{ColO} = 682046.925$$

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

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

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

$$f_c' = 33.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 0.36802142$$

$$V_u = 3.6540709E-008$$

$$d = 0.8 * h = 600.00$$

$$N_u = 9867.326$$

$$A_g = 187500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 465424.857$$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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

$$s/d = 0.75$$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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

$$s/d = 0.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 572420.244$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 682046.925$

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

$$V_{ColO} = 682046.925$$

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

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

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

$f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.36791177$

$V_u = 3.6540709E-008$

$d = 0.8 \cdot h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 0.75$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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: $V_s + V_f \leq 572420.244$

$b_w = 250.00$

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $I_b/I_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 154158.603$
Shear Force, $V2 = 2785.183$
Shear Force, $V3 = -104.8793$
Axial Force, $F = -10296.313$
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: $A_{s,ten} = 1231.504$
-Compression: $A_{s,com} = 1231.504$
-Middle: $A_{s,mid} = 2689.203$
Mean Diameter of Tension Reinforcement, $DbL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.00052955$
 $u = y + p = 0.00052955$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00052955$ ((4.29), Biskinis Phd))
 $M_y = 3.9374E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.4354E+013$
factor = 0.30
 $A_g = 262500.00$
 $f_c' = 33.00$
 $N = 10296.313$
 $E_c * I_g = 2.4785E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1941313E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 311.2112$
 $d = 707.00$
 $y = 0.31094644$
 $A = 0.0293369$
 $B = 0.01564849$
with $p_t = 0.00696749$
 $p_c = 0.00696749$
 $p_v = 0.01521473$
 $N = 10296.313$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0047538E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.30970808$
 $A = 0.02901732$
 $B = 0.01546131$
with $E_s = 200000.00$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_{yE}/V_{CoIE} = 0.56523739$

$d = 707.00$

$s = 0.00$

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

$A_v = 78.53982$, 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.

$NUD = 10296.313$

$A_g = 262500.00$

$f_{cE} = 33.00$

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

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

$b = 250.00$

$d = 707.00$

$f_{cE} = 33.00$

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

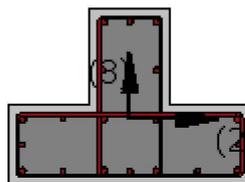
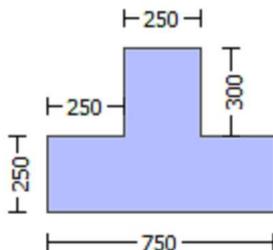
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column 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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3370E+007$

Shear Force, $V_a = -4375.009$

EDGE -B-

Bending Moment, $M_b = 242154.535$

Shear Force, $V_b = 4375.009$

BOTH EDGES

Axial Force, $F = -10541.185$

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: $A_{sl,ten} = 1231.504$

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

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

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 513344.984$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 513344.984$

$V_{CoI} = 513344.984$

$k_n = 1.00$

displacement_ductility_demand = 0.01436651

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'

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)

$M/Vd = 4.00$

$\mu_u = 1.3370E+007$

$V_u = 4375.009$

$d = 0.8 \cdot h = 600.00$

$N_u = 10541.185$

$A_g = 187500.00$

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: $V_s + V_f \leq 498227.872$

$b_w = 250.00$

displacement ductility demand is calculated as δ / y

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

From analysis, chord rotation $\theta = 7.7512328E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00539535$ ((4.29), Biskinis Phd)

$M_y = 3.9380E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3056.073

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 7.4354E+013$

factor = 0.30

$A_g = 262500.00$

$f_c' = 33.00$

$N = 10541.185$

$E_c \cdot I_g = 2.4785E+014$

Calculation of Yielding Moment M_y

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

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

$y_{ten} = 3.1943307E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 311.2112$

$d = 707.00$

$y = 0.31098945$

$A = 0.02934135$

$B = 0.01565294$

with $pt = 0.00696749$

$pc = 0.00696749$

$p_v = 0.01521473$

$N = 10541.185$

$b = 250.00$

" = 0.06082037

y_comp = 1.0047091E-005
with fc = 33.00
Ec = 26999.444
y = 0.30972185
A = 0.02901417
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

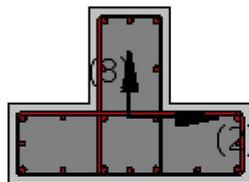
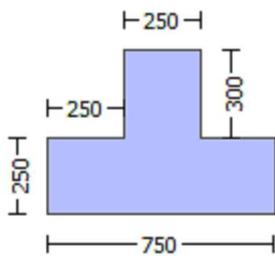
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
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,  $f_c = f_{cm} = 33.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
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,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
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 = 1.00
Element Length,  $L = 3000.00$ 
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$ 
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:  $A_{sl,mid} = 2060.885$ 
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.88728525$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$ 
with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 6.0162E+008$ 
   $M_{u1+} = 6.0162E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
  which is defined for the static loading combination
   $M_{u1-} = 2.9288E+008$ , 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
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 6.0162E+008$ 
   $M_{u2+} = 6.0162E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
  which is defined for the the static loading combination
   $M_{u2-} = 2.9288E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
  direction which is defined for the the static loading combination
-----

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

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

```

u = 1.5713663E-005
Mu = 6.0162E+008

with full section properties:

b = 250.00

d = 507.00

d' = 43.00

v = 0.00235905

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

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

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

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

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 $b_i^2/6$ as defined at (A.2).

$psh_{\text{min}} = \text{Min}(psh_x, psh_y) = 0.00271274$

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

psh_x ((5.4d), 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 ((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

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

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

c = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

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

$l_0/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal}$ ((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 $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2_nominal} = 0.08$,

For calculation of $e_{su2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s2} = f_s = 389.0139$$

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

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

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

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

$$\text{with } f_{sv} = f_s = 389.0139$$

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.21037088$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07713599$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.26806058$$

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

--->

$$s_u (4.8) = 0.35733511$$

$$M_u = M_{Rc} (4.15) = 6.0162E+008$$

$$u = s_u (4.1) = 1.5713663E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u1} -

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

$$u = 1.1952435E-005$$

$$M_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

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

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 $b_i d / 6$ as defined at (A.2).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o / l_{ou,min} = l_b / d = 0.30$$

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

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

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.

$$\text{with } fs_1 = fs = 389.0139$$

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

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

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

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 0.30$$

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

From table 5A.1, TBDY: $e_{s_u2,nominal} = 0.08$,

For calculation of $e_{s_u2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{s_y2} = f_{s_2}/1.2$, 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.

$$\text{with } f_{s_2} = f_s = 389.0139$$

$$\text{with } E_{s_2} = E_s = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{u_v} = 0.00512$$

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

$$l_o/l_{o,u,min} = l_b/l_d = 0.30$$

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

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

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v},nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.

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

$$\text{with } f_{s_v} = f_s = 389.0139$$

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

$$1 = A_{s_l,ten}/(b*d)*(f_{s_1}/f_c) = 0.025712$$

$$2 = A_{s_l,com}/(b*d)*(f_{s_2}/f_c) = 0.07012363$$

$$v = A_{s_l,mid}/(b*d)*(f_{s_v}/f_c) = 0.06389042$$

and confined core properties:

$$b = 690.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

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

$$1 = A_{s_l,ten}/(b*d)*(f_{s_1}/f_c) = 0.02970555$$

$$2 = A_{s_l,com}/(b*d)*(f_{s_2}/f_c) = 0.08101513$$

$$v = A_{s_l,mid}/(b*d)*(f_{s_v}/f_c) = 0.07381378$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.15509944$$

$$\mu_u = M_{Rc} (4.14) = 2.9288E+008$$

$$u = s_u (4.1) = 1.1952435E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2+}

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

$$u = 1.5713663E-005$$

$$\mu_u = 6.0162E+008$$

with full section properties:

$$b = 250.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00235905$$

$$N = 9867.326$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

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

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).

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

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

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

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

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

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

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

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

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

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

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

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

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

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_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 $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

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 y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fsv = fs = 389.0139$

with $Es_v = Es = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.21037088$

2 = $Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.07713599$

$v = Asl_{mid}/(b \cdot d) \cdot (fsv/fc) = 0.19167125$

and confined core properties:

$b = 190.00$

$d = 477.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.29421283$

2 = $Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.10787804$

$v = Asl_{mid}/(b \cdot d) \cdot (fsv/fc) = 0.26806058$

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

--->

$su (4.8) = 0.35733511$

$Mu = MRc (4.15) = 6.0162E+008$

$u = su (4.1) = 1.5713663E-005$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 1.1952435E-005$

$Mu = 2.9288E+008$

with full section properties:

$b = 750.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00078635$

$N = 9867.326$

$fc = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

$ase = \text{Max}(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848$

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).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 psh,x ((5.4d), 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

 $s = 150.00$

$fywe = 694.45$

$fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 466.8167$

$fy1 = 389.0139$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/d = 0.30$

$su1 = 0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 389.0139$

with $Es1 = Es = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 466.8167$

$fy2 = 389.0139$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/lb,min = 0.30$

$su2 = 0.4 * esu2_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs2 = fs = 389.0139$

with $Es2 = Es = 200000.00$

yv = 0.00140044
shv = 0.0044814
ftv = 466.8167
fyv = 389.0139
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.025712

2 = Asl,com/(b*d)*(fs2/fc) = 0.07012363

v = Asl,mid/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

b = 690.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02970555

2 = Asl,com/(b*d)*(fs2/fc) = 0.08101513

v = Asl,mid/(b*d)*(fsv/fc) = 0.07381378

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

su (4.9) = 0.15509944

Mu = MRc (4.14) = 2.9288E+008

u = su (4.1) = 1.1952435E-005

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 452028.293

Calculation of Shear Strength at edge 1, Vr1 = 452028.293

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 452028.293

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' = 33.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 645.4488

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 = 372339.886

where:

Vs1 = 255983.671 is calculated for section web, with:

d = 440.00

Av = 157079.633

fy = 555.56

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 116356.214 is calculated for section flange, with:

d = 200.00

Av = 157079.633

fy = 555.56

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 <= 419774.846

bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 452028.293

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 452028.293

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' = 33.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 645.4488

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 = 372339.886

where:

Vs1 = 255983.671 is calculated for section web, with:

d = 440.00

Av = 157079.633

fy = 555.56

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 116356.214 is calculated for section flange, with:

d = 200.00

Av = 157079.633

fy = 555.56

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 <= 419774.846

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

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 = 1.00

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6540709E-008$

EDGE -B-

Shear Force, $V_b = -3.6540709E-008$

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: $A_{st,ten} = 1231.504$

-Compression: $A_{sl,com} = 1231.504$

-Middle: $A_{sl,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56523739$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.7828E+008$

$M_{u1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.7828E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.7828E+008$

$M_{u2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.7828E+008$, 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 Mu1+

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 9.2773974E-006$$

$$Mu = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along } Y) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along } X) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou,min} = l_b / d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

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.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

2 = Asl,com/(b*d)*(fs2/fc) = 0.11286126

v = Asl,mid/(b*d)*(fsv/fc) = 0.24645214

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

su (4.9) = 0.21940748

Mu = MRc (4.14) = 5.7828E+008

u = su (4.1) = 9.2773974E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.2773974E-006
Mu = 5.7828E+008

with full section properties:

b = 250.00

d = 707.00

d' = 43.00

v = 0.00169171

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

$ase = \text{Max}(((Aconf,max - AnoConf) / Aconf,max) * (Aconf,min / Aconf,max), 0) = 0.28820848$

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).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x ((5.4d), 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo,min = lb/d = 0.30$

$su1 = 0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 389.0139$

with $Es1 = Es = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$

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 $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$su_v = 0.4 * esu_{v,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{v,nominal} = 0.08$,

considering characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsy_v = fsv/1.2$, 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 $fsv = fs = 389.0139$

with $Es_v = Es = 200000.00$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.0821349$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.0821349$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = A_{sl,ten}/(b*d) * (fs_1/f_c) = 0.11286126$

$2 = A_{sl,com}/(b*d) * (fs_2/f_c) = 0.11286126$

$v = A_{sl,mid}/(b*d) * (fsv/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.21940748$

$Mu = MRc (4.14) = 5.7828E+008$

$u = su (4.1) = 9.2773974E-006$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_{2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 9.2773974E-006$

$Mu = 5.7828E+008$

with full section properties:

$b = 250.00$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $es_{u2_nominal} = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$s_{uv} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{u,min} = lb/d = 0.30$

$s_{uv} = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_v = fs = 389.0139$

with $Es_v = Es = 200000.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.0821349$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.0821349$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11286126$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.11286126$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.21940748$

$\mu_u = MR_c (4.14) = 5.7828E+008$

$u = s_u (4.1) = 9.2773974E-006$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of μ_{u2} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 9.2773974E-006$

$\mu_u = 5.7828E+008$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00169171$

$N = 9867.326$

$f_c = 33.00$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d), TBDY} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ (5.4d), TBDY} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_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.

$$\text{with } fs_2 = fs = 389.0139$$

with $E_s = E_s = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 466.8167$
 $fy_v = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 389.0139$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.0821349$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.0821349$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.17935581$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl_{ten}/(b*d) * (fs_1/fc) = 0.11286126$
 $2 = Asl_{com}/(b*d) * (fs_2/fc) = 0.11286126$
 $v = Asl_{mid}/(b*d) * (fsv/fc) = 0.24645214$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->

$su (4.9) = 0.21940748$
 $Mu = MRc (4.14) = 5.7828E+008$
 $u = su (4.1) = 9.2773974E-006$

 Calculation of ratio lb/ld

 Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 682046.925$

 Calculation of Shear Strength at edge 1, $V_{r1} = 682046.925$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 682046.925$
 $knl = 1$ (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)
 $fc' = 33.00$, but $fc'^{0.5} <= 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 0.36802142$
 $Vu = 3.6540709E-008$
 $d = 0.8 * h = 600.00$
 $Nu = 9867.326$
 $Ag = 187500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.75$$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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: $V_s + V_f \leq 572420.244$

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 682046.925$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$$V_{Col0} = 682046.925$$

$k_{nl} = 1$ (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)

$f_c' = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 0.36791177$$

$$V_u = 3.6540709E-008$$

$$d = 0.8 * h = 600.00$$

$$N_u = 9867.326$$

$$A_g = 187500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.75$$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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: $V_s + V_f \leq 572420.244$

$$bw = 250.00$$

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, $\phi = 1.00$

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -321280.516$

Shear Force, $V_2 = -4375.009$

Shear Force, $V_3 = 164.7459$

Axial Force, $F = -10541.185$

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 $\phi_{u,R} = 1.0^* \phi_u = 0.02353212$

$\phi_u = \phi_y + \phi_p = 0.02353212$

- Calculation of ϕ_y -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00550567$ ((4.29), Biskinis Phd))

$M_y = 3.8351E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1950.157

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$

factor = 0.30

$A_g = 262500.00$

$f_c' = 33.00$

$N = 10541.185$

$E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 5.1441692\text{E-}006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25*f_y*(l_b/d)^{2/3}) = 311.2112$
 $d = 507.00$
 $y = 0.40337431$
 $A = 0.04091585$
 $B = 0.02748716$
 with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10541.185$
 $b = 250.00$
 $" = 0.08481262$
 $y_{\text{comp}} = 1.0781043\text{E-}005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.40249722$
 $A = 0.04045961$
 $B = 0.02721993$
 with $E_s = 200000.00$

 Calculation of ratio l_b/d

 Inadequate Lap Length with $l_b/d = 0.30$

 - Calculation of p -

 From table 10-8: $p = 0.01802644$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 0.88728525$

$d = 507.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = A_v * L_{\text{stir}} / (A_g * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, is the area of every stirrup

$L_{\text{stir}} = 1360.00$, 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.

$N_{UD} = 10541.185$

$A_g = 262500.00$

$f_{cE} = 33.00$

$f_{ytE} = f_{ylE} = 0.00$

$p_l = \text{Area_Tot_Long_Rein} / (b * d) = 0.04064862$

$b = 250.00$

$d = 507.00$

$f_{cE} = 33.00$

 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

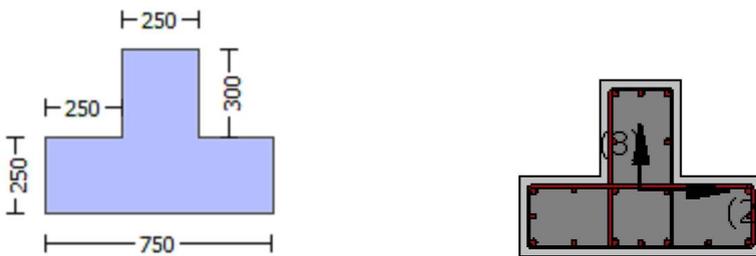
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column 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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = l_b/d = 0.30$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -321280.516$
Shear Force, $V_a = 164.7459$
EDGE -B-
Bending Moment, $M_b = -172405.152$
Shear Force, $V_b = -164.7459$
BOTH EDGES
Axial Force, $F = -10541.185$
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: $A_{s,ten} = 2261.947$
-Compression: $A_{s,com} = 829.3805$
-Middle: $A_{s,mid} = 2060.885$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 * V_n = 404655.68$
 $V_n ((10.3), ASCE 41-17) = k_n l * V_{CoI} = 404655.68$
 $V_{CoI} = 404655.68$
 $k_n l = 1.00$
 $displacement_ductility_demand = 0.00251487$

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)
 $f_c' = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 321280.516$
 $V_u = 164.7459$
 $d = 0.8 * h = 440.00$
 $N_u = 10541.185$
 $A_g = 137500.00$
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 $\theta = 1.3846032E-005$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00550567$ ((4.29), Biskinis Phd))
 $M_y = 3.8351E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1950.157
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 33.00$
 $N = 10541.185$
 $E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 5.1441692E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 311.2112$
 $d = 507.00$
 $y = 0.40337431$
 $A = 0.04091585$
 $B = 0.02748716$
with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10541.185$
 $b = 250.00$
 $\rho = 0.08481262$
 $y_{comp} = 1.0781043E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.40249722$
 $A = 0.04045961$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Inadequate Lap Length with $I_b / I_d = 0.30$

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

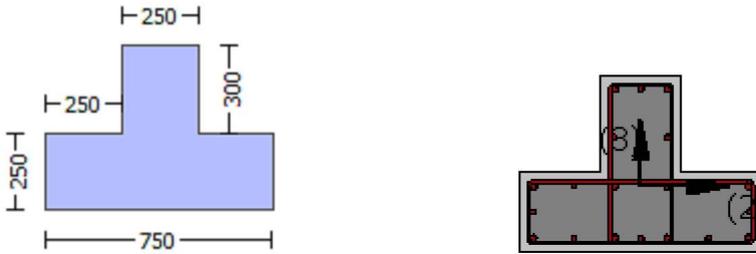
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column 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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 * f_{sm} = 694.45$

#####

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 = 1.00

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = 0.30$

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: $A_{s,ten} = 2261.947$

-Compression: $A_{s,com} = 829.3805$

-Middle: $A_{s,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.88728525$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 6.0162E+008$

$M_{u1+} = 6.0162E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.9288E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 6.0162E+008$

$M_{u2+} = 6.0162E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 2.9288E+008$, 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:

$\phi_u = 1.5713663E-005$

$M_u = 6.0162E+008$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00235905$

$N = 9867.326$

$f_c = 33.00$

$\alpha = 0.002$ (5A.5, TBDY)

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00631023$

ϕ_c (5.4c) = 0.00493587

$\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

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).

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

$$\text{psh}_x \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00271274$$

$$\text{Lstir (Length of stirrups along Y)} = 1760.00$$

$$\text{Astir (stirrups area)} = 78.53982$$

$$\text{Asec (section area)} = 262500.00$$

$$\text{psh}_y \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00351061$$

$$\text{Lstir (Length of stirrups along X)} = 1360.00$$

$$\text{Astir (stirrups area)} = 78.53982$$

$$\text{Asec (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 389.0139$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$su_v = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_v = 0.4 * esu_{v,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_{v,nominal} = 0.08$,

considering characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Es_v = Es = 200000.00$$

$$1 = \text{Asl,ten} / (b * d) * (fs_1 / fc) = 0.21037088$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07713599$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.26806058$$

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

--->

$$s_u (4.8) = 0.35733511$$

$$M_u = M_{Rc} (4.15) = 6.0162E+008$$

$$u = s_u (4.1) = 1.5713663E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_u1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1952435E-005$$

$$M_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = 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 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139
with Es1 = Es = 200000.00

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139
with Es2 = Es = 200000.00

yv = 0.00140044
shv = 0.0044814
ftv = 466.8167
fyv = 389.0139
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.025712
2 = Asl,com/(b*d)*(fs2/fc) = 0.07012363
v = Asl,mid/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

$b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.02970555$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08101513$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07381378$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.15509944$
 $Mu = MRc (4.14) = 2.9288E+008$
 $u = su (4.1) = 1.1952435E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 1.5713663E-005$
 $Mu = 6.0162E+008$

 with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00235905$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$
 $w_e (5.4c) = 0.00493587$

$ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.21037088

2 = Asl,com/(b*d)*(fs2/fc) = 0.07713599

v = Asl,mid/(b*d)*(fsv/fc) = 0.19167125

and confined core properties:

b = 190.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

$c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29421283$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10787804$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.26806058$

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

--->
 $s_u(4.8) = 0.35733511$
 $M_u = MR_c(4.15) = 6.0162E+008$
 $u = s_u(4.1) = 1.5713663E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of M_u2 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 1.1952435E-005$
 $M_u = 2.9288E+008$

 with full section properties:

$b = 750.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00078635$
 $N = 9867.326$
 $f_c = 33.00$
 $c_o(5A.5, TBDY) = 0.002$

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.00631023$

$w_e(5.4c) = 0.00493587$
 $a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

 $p_{sh,x}((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

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

$s = 150.00$
 $fy_{we} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 466.8167$
 $fy_1 = 389.0139$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 389.0139$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 466.8167$
 $fy_2 = 389.0139$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 389.0139$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 466.8167$
 $fy_v = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 389.0139$
 with $Esv = Es = 200000.00$
 $1 = Asl, \text{ten}/(b*d) * (fs_1/fc) = 0.025712$
 $2 = Asl, \text{com}/(b*d) * (fs_2/fc) = 0.07012363$
 $v = Asl, \text{mid}/(b*d) * (fsv/fc) = 0.06389042$
 and confined core properties:
 $b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten}/(b*d) * (fs_1/fc) = 0.02970555$
 $2 = Asl, \text{com}/(b*d) * (fs_2/fc) = 0.08101513$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07381378$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.15509944$$

$$M_u = M_{Rc}(4.14) = 2.9288E+008$$

$$u = s_u(4.1) = 1.1952435E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 452028.293$

Calculation of Shear Strength at edge 1, $V_{r1} = 452028.293$

$$V_{r1} = V_{Col}((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 452028.293$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 4.00$$

$$M_u = 645.4488$$

$$V_u = 0.00014703$$

$$d = 0.8 \cdot h = 440.00$$

$$N_u = 9867.326$$

$$A_g = 137500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 372339.886$$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$$d = 440.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.34090909$$

$V_{s2} = 116356.214$ is calculated for section flange, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s2} is multiplied by $Col2 = 1.00$

$$s/d = 0.75$$

$$V_f((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 419774.846$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 452028.293$

$$V_{r2} = V_{Col}((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 452028.293$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$M/Vd = 4.00$
 $\mu_u = 645.4488$
 $V_u = 0.00014703$
 $d = 0.8 \cdot h = 440.00$
 $N_u = 9867.326$
 $A_g = 137500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$
 where:
 $V_{s1} = 255983.671$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 116356.214$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 150.00$
 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: $V_s + V_f \leq 419774.846$
 $b_w = 250.00$

 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, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 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 = 1.00
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6540709E-008$

EDGE -B-

Shear Force, $V_b = -3.6540709E-008$

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: $As_{c,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56523739$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.7828E+008$
 $Mu_{1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.7828E+008$
 $Mu_{2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $Mu_{2-} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 9.2773974E-006$

$Mu = 5.7828E+008$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00169171$

$N = 9867.326$

$f_c = 33.00$

$\alpha (5A.5, TBDY) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00631023$

$\phi_{we} (5.4c) = 0.00493587$

$\alpha_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$su_v = 0.4 * esu_{v,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu_{v,nominal} = 0.08$,

considering characteristic value $fsy_v = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 389.0139$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0821349$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0821349$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11286126$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11286126$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21940748$
 $Mu = MRc (4.14) = 5.7828E+008$
 $u = su (4.1) = 9.2773974E-006$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_1 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 9.2773974E-006$
 $Mu = 5.7828E+008$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$
 $w_e (5.4c) = 0.00493587$
 $ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) \cdot (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$
 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).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$
 Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

$$\text{psh}_x \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00271274$$

$$\text{Lstir (Length of stirrups along Y)} = 1760.00$$

$$\text{Astir (stirrups area)} = 78.53982$$

$$\text{Asec (section area)} = 262500.00$$

$$\text{psh}_y \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00351061$$

$$\text{Lstir (Length of stirrups along X)} = 1360.00$$

$$\text{Astir (stirrups area)} = 78.53982$$

$$\text{Asec (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 389.0139$$

$$\text{with } Es_2 = Es = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.0821349$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along } Y) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11286126$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->
 $su (4.9) = 0.21940748$
 $Mu = MRc (4.14) = 5.7828E+008$
 $u = su (4.1) = 9.2773974E-006$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_2 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 9.2773974E-006$
 $Mu = 5.7828E+008$

 with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$
 $w_e (5.4c) = 0.00493587$

$ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

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

Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.

with fs1 = fs = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->
v < v_{s,y2} - LHS eq.(4.5) is satisfied

---->
su (4.9) = 0.21940748
Mu = MRc (4.14) = 5.7828E+008
u = su (4.1) = 9.2773974E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 682046.925

Calculation of Shear Strength at edge 1, Vr1 = 682046.925

$$Vr1 = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$$

$$V_{ColO} = 682046.925$$

$$knl = 1 \text{ (zero step-static loading)}$$

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)

$$f_c' = 33.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 0.36802142$$

$$Vu = 3.6540709E-008$$

$$d = 0.8*h = 600.00$$

$$Nu = 9867.326$$

$$Ag = 187500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 465424.857$$

where:

Vs1 = 116356.214 is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.75$$

Vs2 = 349068.643 is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.25$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 572420.244$$

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, Vr2 = 682046.925

$$Vr2 = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$$

$$V_{ColO} = 682046.925$$

$$knl = 1 \text{ (zero step-static loading)}$$

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)

$f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.36791177$

$V_u = 3.6540709E-008$

$d = 0.8 \cdot h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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: $V_s + V_f \leq 572420.244$

$b_w = 250.00$

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: (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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.3370E+007$
Shear Force, $V2 = -4375.009$
Shear Force, $V3 = 164.7459$
Axial Force, $F = -10541.185$
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: $A_{s,ten} = 1231.504$
-Compression: $A_{s,com} = 1231.504$
-Middle: $A_{s,mid} = 2689.203$
Mean Diameter of Tension Reinforcement, $DbL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.02820898$
 $u = y + p = 0.02820898$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00539535$ ((4.29), Biskinis Phd))
 $M_y = 3.9380E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3056.073
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.4354E+013$
factor = 0.30
 $A_g = 262500.00$
 $f_c' = 33.00$
 $N = 10541.185$
 $E_c * I_g = 2.4785E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1943307E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 311.2112$
 $d = 707.00$
 $y = 0.31098945$
 $A = 0.02934135$
 $B = 0.01565294$
with $p_t = 0.00696749$
 $p_c = 0.00696749$
 $p_v = 0.01521473$
 $N = 10541.185$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0047091E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.30972185$
 $A = 0.02901417$
 $B = 0.01546131$
with $E_s = 200000.00$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.02281363$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_{yE}/V_{CoIE} = 0.56523739$

$d = 707.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = A_v*L_{stir}/(A_g*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00$

$A_v = 78.53982$, 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.

$NUD = 10541.185$

$A_g = 262500.00$

$f_{cE} = 33.00$

$f_{ytE} = f_{ylE} = 0.00$

$p_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.02914971$

$b = 250.00$

$d = 707.00$

$f_{cE} = 33.00$

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

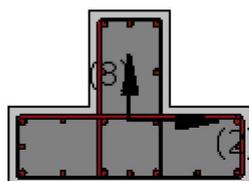
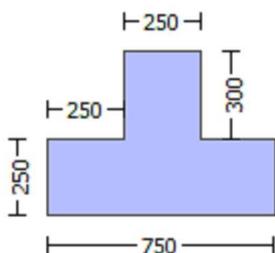
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3370E+007$

Shear Force, $V_a = -4375.009$

EDGE -B-

Bending Moment, $M_b = 242154.535$

Shear Force, $V_b = 4375.009$

BOTH EDGES

Axial Force, $F = -10541.185$

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: $A_{sl,ten} = 1231.504$

-Compression: $A_{sl,com} = 1231.504$

-Middle: $A_{sl,mid} = 2689.203$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.60$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 607810.947$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 607810.947$

$V_{CoI} = 607810.947$

$k_n = 1.00$

displacement_ductility_demand = 0.05264187

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*VF'

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)

$M/Vd = 2.00$

$\mu_u = 242154.535$

$V_u = 4375.009$

$d = 0.8 \cdot h = 600.00$

$N_u = 10541.185$

$A_g = 187500.00$

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: $V_s + V_f \leq 498227.872$

$b_w = 250.00$

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 $\theta = 2.7881000E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00052964$ ((4.29), Biskinis Phd)

$M_y = 3.9380E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 7.4354E+013$

factor = 0.30

$A_g = 262500.00$

$f_c' = 33.00$

$N = 10541.185$

$E_c \cdot I_g = 2.4785E+014$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 3.1943307E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 311.2112$

$d = 707.00$

$y = 0.31098945$

$A = 0.02934135$

$B = 0.01565294$

with $pt = 0.00696749$

$pc = 0.00696749$

$pv = 0.01521473$

$N = 10541.185$

$b = 250.00$

" = 0.06082037

y_comp = 1.0047091E-005
with fc = 33.00
Ec = 26999.444
y = 0.30972185
A = 0.02901417
B = 0.01546131
with Es = 200000.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

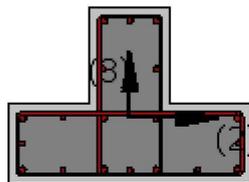
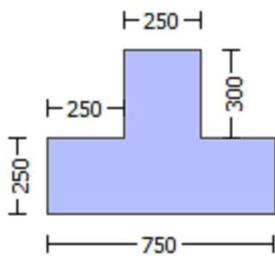
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column TC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

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,  $f_c = f_{cm} = 33.00$ 
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
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,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
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 = 1.00
Element Length,  $L = 3000.00$ 
Primary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$ 
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 ,  $V_e/V_r = 0.88728525$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$ 
with
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 6.0162E+008$ 
   $M_{u1+} = 6.0162E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
  which is defined for the static loading combination
   $M_{u1-} = 2.9288E+008$ , 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
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 6.0162E+008$ 
   $M_{u2+} = 6.0162E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
  which is defined for the the static loading combination
   $M_{u2-} = 2.9288E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
  direction which is defined for the the static loading combination
-----

Calculation of  $M_{u1+}$ 
-----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

```

u = 1.5713663E-005
Mu = 6.0162E+008

with full section properties:

b = 250.00

d = 507.00

d' = 43.00

v = 0.00235905

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

$ase = \text{Max}(((Aconf,max - AnoConf) / Aconf,max) * (Aconf,min / Aconf,max), 0) = 0.28820848$

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).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x ((5.4d), 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: $cc = 0.002$

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo,min = lb/d = 0.30$

$su1 = 0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 389.0139$

with $Es1 = Es = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2_nominal} = 0.08$,

For calculation of $e_{su2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{s2} = f_s = 389.0139$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, 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 $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 389.0139$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.21037088$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.07713599$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.26806058$$

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

--->

$$s_u (4.8) = 0.35733511$$

$$M_u = M_{Rc} (4.15) = 6.0162E+008$$

$$u = s_u (4.1) = 1.5713663E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u1} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1952435E-005$$

$$M_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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 $b_i d / 6$ as defined at (A.2).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou,min} = l_b / d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

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.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{s_u2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_u2,nominal} = 0.08$,

For calculation of $e_{s_u2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{s_y2} = f_{s_2}/1.2$, 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.

$$\text{with } f_{s_2} = f_s = 389.0139$$

$$\text{with } E_{s_2} = E_s = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{u_v} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_d = 0.30$$

$$s_{u_v} = 0.4 * e_{s_{u_v},nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s_{u_v},nominal} = 0.08$,

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v},nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{s_v} = f_s = 389.0139$$

$$\text{with } E_{s_v} = E_s = 200000.00$$

$$1 = A_{s_l,ten}/(b*d)*(f_{s_1}/f_c) = 0.025712$$

$$2 = A_{s_l,com}/(b*d)*(f_{s_2}/f_c) = 0.07012363$$

$$v = A_{s_l,mid}/(b*d)*(f_{s_v}/f_c) = 0.06389042$$

and confined core properties:

$$b = 690.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{s_l,ten}/(b*d)*(f_{s_1}/f_c) = 0.02970555$$

$$2 = A_{s_l,com}/(b*d)*(f_{s_2}/f_c) = 0.08101513$$

$$v = A_{s_l,mid}/(b*d)*(f_{s_v}/f_c) = 0.07381378$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y_2}$ - LHS eq.(4.5) is satisfied

---->

$$s_u (4.9) = 0.15509944$$

$$\mu_u = M_{Rc} (4.14) = 2.9288E+008$$

$$u = s_u (4.1) = 1.1952435E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.5713663E-005$$

$$\mu_u = 6.0162E+008$$

with full section properties:

$$b = 250.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00235905$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

$$a_{se} = \text{Max}(((A_{\text{conf,max}} - A_{\text{noConf}}) / A_{\text{conf,max}}) * (A_{\text{conf,min}} / A_{\text{conf,max}}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ ((5.4d), TBDY)} = L_{\text{stir}} * A_{\text{stir}} / (A_{\text{sec}} * s) = 0.00271274$$

$$L_{\text{stir}} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{\text{stir}} \text{ (stirrups area)} = 78.53982$$

$$A_{\text{sec}} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ ((5.4d), TBDY)} = L_{\text{stir}} * A_{\text{stir}} / (A_{\text{sec}} * s) = 0.00351061$$

$$L_{\text{stir}} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{\text{stir}} \text{ (stirrups area)} = 78.53982$$

$$A_{\text{sec}} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_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 $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.30$

$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

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 y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fsv = fs = 389.0139$

with $Es_v = Es = 200000.00$

1 = $Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.21037088$

2 = $Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.07713599$

v = $Asl_{mid}/(b \cdot d) \cdot (fsv/fc) = 0.19167125$

and confined core properties:

b = 190.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = $Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.29421283$

2 = $Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.10787804$

v = $Asl_{mid}/(b \cdot d) \cdot (fsv/fc) = 0.26806058$

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) = 0.35733511

$Mu = MRc$ (4.15) = 6.0162E+008

u = su (4.1) = 1.5713663E-005

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 1.1952435E-005

$Mu = 2.9288E+008$

with full section properties:

b = 750.00

d = 507.00

d' = 43.00

v = 0.00078635

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

$ase = \text{Max}(((Aconf,max-AnoConf)/Aconf,max)*(Aconf,min/Aconf,max),0) = 0.28820848$

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).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 psh,x ((5.4d), 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

 $s = 150.00$

$fywe = 694.45$

$fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 466.8167$

$fy1 = 389.0139$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/d = 0.30$

$su1 = 0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 389.0139$

with $Es1 = Es = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 466.8167$

$fy2 = 389.0139$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lou,min = lb/lb,min = 0.30$

$su2 = 0.4 * esu2_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs2 = fs = 389.0139$

with $Es2 = Es = 200000.00$

yv = 0.00140044
shv = 0.0044814
ftv = 466.8167
fyv = 389.0139
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.025712

2 = Asl,com/(b*d)*(fs2/fc) = 0.07012363

v = Asl,mid/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

b = 690.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.02970555

2 = Asl,com/(b*d)*(fs2/fc) = 0.08101513

v = Asl,mid/(b*d)*(fsv/fc) = 0.07381378

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

su (4.9) = 0.15509944

Mu = MRc (4.14) = 2.9288E+008

u = su (4.1) = 1.1952435E-005

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 452028.293

Calculation of Shear Strength at edge 1, Vr1 = 452028.293

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 452028.293

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' = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 645.4488

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 = 372339.886

where:

Vs1 = 255983.671 is calculated for section web, with:

d = 440.00

Av = 157079.633

fy = 555.56

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 116356.214 is calculated for section flange, with:

d = 200.00

Av = 157079.633

fy = 555.56

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 <= 419774.846

bw = 250.00

Calculation of Shear Strength at edge 2, Vr2 = 452028.293

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 452028.293

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' = 33.00, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 645.4488

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 = 372339.886

where:

Vs1 = 255983.671 is calculated for section web, with:

d = 440.00

Av = 157079.633

fy = 555.56

s = 150.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.34090909

Vs2 = 116356.214 is calculated for section flange, with:

d = 200.00

Av = 157079.633

fy = 555.56

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 <= 419774.846

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

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 = 1.00

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6540709E-008$

EDGE -B-

Shear Force, $V_b = -3.6540709E-008$

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: $A_{st,ten} = 1231.504$

-Compression: $A_{sc,com} = 1231.504$

-Middle: $A_{sl,mid} = 2689.203$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.56523739$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 5.7828E+008$

$M_{u1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 5.7828E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 5.7828E+008$

$M_{u2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 5.7828E+008$, 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 Mu1+

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 9.2773974E-006$$

$$Mu = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along } Y) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along } X) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/d = 0.30$$

$$su_1 = 0.4 * esu_1_{nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_1_{nominal} = 0.08,$$

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.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with fs2 = fs = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044
shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.30

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.

with fsv = fs = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

2 = Asl,com/(b*d)*(fs2/fc) = 0.11286126

v = Asl,mid/(b*d)*(fsv/fc) = 0.24645214

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

v < vs,y2 - LHS eq.(4.5) is satisfied

su (4.9) = 0.21940748

Mu = MRc (4.14) = 5.7828E+008

u = su (4.1) = 9.2773974E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.2773974E-006
Mu = 5.7828E+008

with full section properties:

b = 250.00

d = 707.00

d' = 43.00

v = 0.00169171

N = 9867.326

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

$ase = \text{Max}(((Aconf,max - AnoConf) / Aconf,max) * (Aconf,min / Aconf,max), 0) = 0.28820848$

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).

$psh,min = \text{Min}(psh,x, psh,y) = 0.00271274$

Expression ((5.4d), TBDY) for psh,min has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

psh,x ((5.4d), 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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$lo/lo,min = lb/d = 0.30$

$su1 = 0.4 * esu1_nominal$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs1 = fs = 389.0139$

with $Es1 = Es = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 0.30$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,

For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{s2} = f_s = 389.0139$$

$$\text{with } E_{s2} = E_s = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$s_{uv} = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_d = 0.30$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, 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 $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } f_{sv} = f_s = 389.0139$$

$$\text{with } E_{sv} = E_s = 200000.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.0821349$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d) * (f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d) * (f_{s2}/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d) * (f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $es_{u2_nominal} = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$s_{uv} = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{u,min} = lb/d = 0.30$

$s_{uv} = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_v = fs = 389.0139$

with $Es_v = Es = 200000.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.0821349$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.0821349$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

1 = $As_{l,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11286126$

2 = $As_{l,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.11286126$

$v = As_{l,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$s_u (4.9) = 0.21940748$

$\mu_u = MR_c (4.14) = 5.7828E+008$

$u = s_u (4.1) = 9.2773974E-006$

Calculation of ratio lb/d

Inadequate Lap Length with $lb/d = 0.30$

Calculation of μ_{u2} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 9.2773974E-006$

$\mu_u = 5.7828E+008$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00169171$

$N = 9867.326$

$f_c = 33.00$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e \text{ (5.4c)} = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} \text{ (5.4d), TBDY} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} \text{ (Length of stirrups along Y)} = 1760.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$p_{sh,y} \text{ (5.4d), TBDY} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} \text{ (Length of stirrups along X)} = 1360.00$$

$$A_{stir} \text{ (stirrups area)} = 78.53982$$

$$A_{sec} \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y_1 = 0.00140044$$

$$sh_1 = 0.0044814$$

$$ft_1 = 466.8167$$

$$fy_1 = 389.0139$$

$$su_1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.30$$

$$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1,nominal} = 0.08,$$

For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fs_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_1 = fs = 389.0139$$

$$\text{with } Es_1 = Es = 200000.00$$

$$y_2 = 0.00140044$$

$$sh_2 = 0.0044814$$

$$ft_2 = 466.8167$$

$$fy_2 = 389.0139$$

$$su_2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.30$$

$$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2,nominal} = 0.08,$$

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fs_2 = fs = 389.0139$$

with $E_s = E_s = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 466.8167$
 $fy_v = 389.0139$
 $suv = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 0.30$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fsv = fs = 389.0139$
 with $Esv = Es = 200000.00$
 $1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.0821349$
 $2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.0821349$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.17935581$
 and confined core properties:
 $b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl_{ten}/(b*d)*(fs_1/fc) = 0.11286126$
 $2 = Asl_{com}/(b*d)*(fs_2/fc) = 0.11286126$
 $v = Asl_{mid}/(b*d)*(fsv/fc) = 0.24645214$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

Calculation of ratio lb/ld

Inadequate Lap Length with $lb/ld = 0.30$

Calculation of Shear Strength $V_r = Min(V_{r1}, V_{r2}) = 682046.925$

Calculation of Shear Strength at edge 1, $V_{r1} = 682046.925$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$

$V_{Col0} = 682046.925$

$knl = 1$ (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)

$fc' = 33.00$, but $fc^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 0.36802142$

$Vu = 3.6540709E-008$

$d = 0.8 * h = 600.00$

$Nu = 9867.326$

$Ag = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.75$$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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: $V_s + V_f \leq 572420.244$

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 682046.925$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$$V_{Col0} = 682046.925$$

$k_{nl} = 1$ (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)

$f_c' = 33.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 0.36791177$$

$$V_u = 3.6540709E-008$$

$$d = 0.8 * h = 600.00$$

$$N_u = 9867.326$$

$$A_g = 187500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.75$$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

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: $V_s + V_f \leq 572420.244$

$$bw = 250.00$$

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, $\phi = 1.00$

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -172405.152$

Shear Force, $V_2 = 4375.009$

Shear Force, $V_3 = -164.7459$

Axial Force, $F = -10541.185$

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 $u_{,R} = 1.0^* u = 0.02098089$

$u = y + p = 0.02098089$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00295445$ ((4.29), Biskinis Phd))

$M_y = 3.8351E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1046.491

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$

factor = 0.30

$A_g = 262500.00$

$f_c' = 33.00$

$N = 10541.185$

$E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

```

y = Min( y_ten, y_com)
y_ten = 5.1441692E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/d)^2/3) = 311.2112
d = 507.00
y = 0.40337431
A = 0.04091585
B = 0.02748716
with pt = 0.01784573
pc = 0.00654344
pv = 0.01625945
N = 10541.185
b = 250.00
" = 0.08481262
y_comp = 1.0781043E-005
with fc = 33.00
Ec = 26999.444
y = 0.40249722
A = 0.04045961
B = 0.02721993
with Es = 200000.00

```

Calculation of ratio lb/d

Inadequate Lap Length with lb/d = 0.30

- Calculation of p -

From table 10-8: $p = 0.01802644$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/d \geq 1$

shear control ratio $V_y E / V_{ColOE} = 0.88728525$

$d = 507.00$

$s = 0.00$

$t = A_v / (b_w * s) + 2 * t_f / b_w * (f_{fe} / f_s) = A_v * L_{stir} / (A_g * s) + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00$

$A_v = 78.53982$, 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.

$NUD = 10541.185$

$A_g = 262500.00$

$f_{cE} = 33.00$

$f_{ytE} = f_{ylE} = 0.00$

$pl = \text{Area_Tot_Long_Rein} / (b * d) = 0.04064862$

$b = 250.00$

$d = 507.00$

$f_{cE} = 33.00$

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

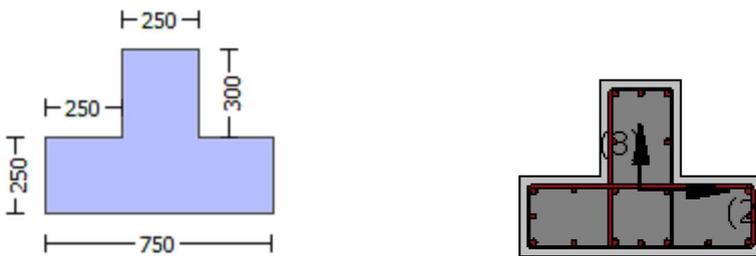
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column 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, $E_c = 26999.444$

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, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.56$

#####

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with $l_o/l_{ou,min} = l_b/d = 0.30$
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -321280.516$
Shear Force, $V_a = 164.7459$
EDGE -B-
Bending Moment, $M_b = -172405.152$
Shear Force, $V_b = -164.7459$
BOTH EDGES
Axial Force, $F = -10541.185$
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: $A_{s,ten} = 2261.947$
-Compression: $A_{s,com} = 829.3805$
-Middle: $A_{s,mid} = 2060.885$
Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 17.77778$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 * V_n = 452077.304$
 V_n ((10.3), ASCE 41-17) = $k_n * V_{CoI} = 452077.304$
 $V_{CoI} = 452077.304$
 $k_n = 1.00$
 $displacement_ductility_demand = 5.2920324E-006$

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)
 $f_c' = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.37839$
 $M_u = 172405.152$
 $V_u = 164.7459$
 $d = 0.8 * h = 440.00$
 $N_u = 10541.185$
 $A_g = 137500.00$
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 B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 1.5635033E-008$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00295445$ ((4.29), Biskinis Phd))
 $M_y = 3.8351E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1046.491
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 4.5281E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $f_c' = 33.00$
 $N = 10541.185$
 $E_c * I_g = 1.5094E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ / y and M_y according to Annex 7 -

 $y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 5.1441692E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 311.2112$
 $d = 507.00$
 $y = 0.40337431$
 $A = 0.04091585$
 $B = 0.02748716$
with $p_t = 0.01784573$
 $p_c = 0.00654344$
 $p_v = 0.01625945$
 $N = 10541.185$
 $b = 250.00$
 $\rho = 0.08481262$
 $y_{comp} = 1.0781043E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.40249722$
 $A = 0.04045961$
 $B = 0.02721993$
with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Inadequate Lap Length with $l_b / l_d = 0.30$

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

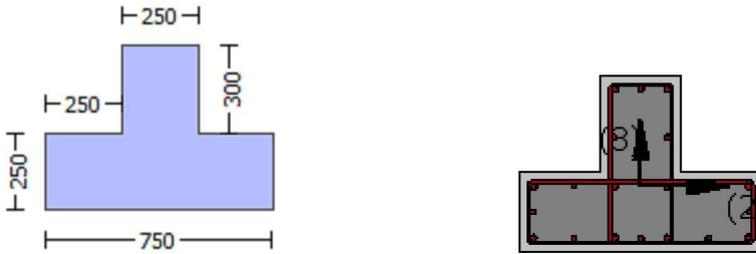
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

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 = 1.00

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $l_o/l_{o,min} = 0.30$

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: $A_{s,ten} = 2261.947$

-Compression: $A_{s,com} = 829.3805$

-Middle: $A_{s,mid} = 2060.885$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.88728525$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 401078.039$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 6.0162E+008$

$M_{u1+} = 6.0162E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.9288E+008$, 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

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 6.0162E+008$

$M_{u2+} = 6.0162E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 2.9288E+008$, 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:

$\phi_u = 1.5713663E-005$

$M_u = 6.0162E+008$

with full section properties:

$b = 250.00$

$d = 507.00$

$d' = 43.00$

$v = 0.00235905$

$N = 9867.326$

$f_c = 33.00$

$\alpha = 0.002$ (5A.5, TBDY)

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00631023$

ϕ_c (5.4c) = 0.00493587

$\phi_{ase} = \text{Max}(((A_{conf,max} - A_{noConf}) / A_{conf,max}) * (A_{conf,min} / A_{conf,max}), 0) = 0.28820848$

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).

$\phi_{psh,min} = \text{Min}(\phi_{psh,x}, \phi_{psh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $\phi_{psh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

$$psh,x ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00271274$$

$$Lstir \text{ (Length of stirrups along Y)} = 1760.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$psh,y ((5.4d), TBDY) = Lstir * Astir / (Asec * s) = 0.00351061$$

$$Lstir \text{ (Length of stirrups along X)} = 1360.00$$

$$Astir \text{ (stirrups area)} = 78.53982$$

$$Asec \text{ (section area)} = 262500.00$$

$$s = 150.00$$

$$fywe = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs1 = fs = 389.0139$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.30$$

$$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fs2 = fs = 389.0139$$

$$\text{with } Es2 = Es = 200000.00$$

$$yv = 0.00140044$$

$$shv = 0.0044814$$

$$ftv = 466.8167$$

$$fyv = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/d = 0.30$$

$$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_nominal = 0.08,$$

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.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/d)^{2/3}), \text{ from 10.3.5, ASCE41-17.}$$

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.21037088$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07713599$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.19167125$$

and confined core properties:

$$b = 190.00$$

$$d = 477.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.26806058$$

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

--->

$$s_u (4.8) = 0.35733511$$

$$M_u = M_{Rc} (4.15) = 6.0162E+008$$

$$u = s_u (4.1) = 1.5713663E-005$$

Calculation of ratio l_b/d

Inadequate Lap Length with $l_b/d = 0.30$

Calculation of M_u1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1952435E-005$$

$$M_u = 2.9288E+008$$

with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

Lstir (Length of stirrups along Y) = 1760.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

psh,y ((5.4d), TBDY) = 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 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 466.8167
fy1 = 389.0139
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139
with Es1 = Es = 200000.00

y2 = 0.00140044
sh2 = 0.0044814
ft2 = 466.8167
fy2 = 389.0139
su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139
with Es2 = Es = 200000.00

yv = 0.00140044
shv = 0.0044814
ftv = 466.8167
fyv = 389.0139
suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139
with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.025712
2 = Asl,com/(b*d)*(fs2/fc) = 0.07012363
v = Asl,mid/(b*d)*(fsv/fc) = 0.06389042

and confined core properties:

$b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.02970555$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08101513$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07381378$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.15509944$
 $Mu = MRc (4.14) = 2.9288E+008$
 $u = su (4.1) = 1.1952435E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 1.5713663E-005$
 $Mu = 6.0162E+008$

 with full section properties:

$b = 250.00$
 $d = 507.00$
 $d' = 43.00$
 $v = 0.00235905$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.00631023$
 $w_e (5.4c) = 0.00493587$

$ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

Lstir (Length of stirrups along X) = 1360.00
Astir (stirrups area) = 78.53982
Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.21037088

2 = Asl,com/(b*d)*(fs2/fc) = 0.07713599

v = Asl,mid/(b*d)*(fsv/fc) = 0.19167125

and confined core properties:

b = 190.00

d = 477.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.29421283$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.10787804$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.26806058$$

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

--->
 $s_u(4.8) = 0.35733511$
 $\mu_u = MR_c(4.15) = 6.0162E+008$
 $u = s_u(4.1) = 1.5713663E-005$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of μ_u -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1952435E-005$$

$$\mu_u = 2.9288E+008$$

 with full section properties:

$$b = 750.00$$

$$d = 507.00$$

$$d' = 43.00$$

$$v = 0.00078635$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.00631023$

$$w_e(5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

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).
 $p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x}((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$
 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

$s = 150.00$
 $fy_{we} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.002$
 $c = \text{confinement factor} = 1.00$
 $y_1 = 0.00140044$
 $sh_1 = 0.0044814$
 $ft_1 = 466.8167$
 $fy_1 = 389.0139$
 $su_1 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_1 = fs = 389.0139$
 with $Es_1 = Es = 200000.00$
 $y_2 = 0.00140044$
 $sh_2 = 0.0044814$
 $ft_2 = 466.8167$
 $fy_2 = 389.0139$
 $su_2 = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 0.30$
 $su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_2 = fs = 389.0139$
 with $Es_2 = Es = 200000.00$
 $y_v = 0.00140044$
 $sh_v = 0.0044814$
 $ft_v = 466.8167$
 $fy_v = 389.0139$
 $su_v = 0.00512$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/d = 0.30$
 $su_v = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, 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 $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE41-17.
 with $fs_v = fs = 389.0139$
 with $Es_v = Es = 200000.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.025712$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.07012363$
 $v = Asl, \text{mid}/(b * d) * (fs_v/fc) = 0.06389042$
 and confined core properties:
 $b = 690.00$
 $d = 477.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.00$
 $cc \text{ (5A.5, TBDY)} = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = Asl, \text{ten}/(b * d) * (fs_1/fc) = 0.02970555$
 $2 = Asl, \text{com}/(b * d) * (fs_2/fc) = 0.08101513$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07381378$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.15509944$$

$$M_u = M_{Rc}(4.14) = 2.9288E+008$$

$$u = s_u(4.1) = 1.1952435E-005$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 452028.293$

Calculation of Shear Strength at edge 1, $V_{r1} = 452028.293$

$$V_{r1} = V_{Col}((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 452028.293$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 4.00$$

$$M_u = 645.4488$$

$$V_u = 0.00014703$$

$$d = 0.8 \cdot h = 440.00$$

$$N_u = 9867.326$$

$$A_g = 137500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 372339.886$$

where:

$V_{s1} = 255983.671$ is calculated for section web, with:

$$d = 440.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.34090909$$

$V_{s2} = 116356.214$ is calculated for section flange, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

V_{s2} is multiplied by $Col2 = 1.00$

$$s/d = 0.75$$

$$V_f((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 419774.846$$

$$b_w = 250.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 452028.293$

$$V_{r2} = V_{Col}((10.3), ASCE 41-17) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 452028.293$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 33.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$M/Vd = 4.00$
 $\mu_u = 645.4488$
 $V_u = 0.00014703$
 $d = 0.8 \cdot h = 440.00$
 $N_u = 9867.326$
 $A_g = 137500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 372339.886$
 where:
 $V_{s1} = 255983.671$ is calculated for section web, with:
 $d = 440.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 150.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.34090909$
 $V_{s2} = 116356.214$ is calculated for section flange, with:
 $d = 200.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 150.00$
 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: $V_s + V_f \leq 419774.846$
 $b_w = 250.00$

 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, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 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, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 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 = 1.00
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Inadequate Lap Length with $l_o/l_{ou,min} = 0.30$
 No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 3.6540709E-008$

EDGE -B-

Shear Force, $V_b = -3.6540709E-008$

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, $V_e/V_r = 0.56523739$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 385518.422$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 5.7828E+008$
 $Mu_{1+} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 5.7828E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 5.7828E+008$
 $Mu_{2+} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $Mu_{2-} = 5.7828E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 9.2773974E-006$

$M_u = 5.7828E+008$

with full section properties:

$b = 250.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00169171$

$N = 9867.326$

$f_c = 33.00$

ω (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.00631023$

ω_e (5.4c) = 0.00493587

$\omega_{ase} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

 $p_{sh,x} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$

L_{stir} (Length of stirrups along Y) = 1760.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $p_{sh,y} \text{ ((5.4d), TBDY)} = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$

L_{stir} (Length of stirrups along X) = 1360.00

A_{stir} (stirrups area) = 78.53982

A_{sec} (section area) = 262500.00

 $s = 150.00$

$f_{ywe} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 466.8167$

$fy_1 = 389.0139$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 * esu_{1,nominal} \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_1 = fs = 389.0139$

with $Es_1 = Es = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 466.8167$

$fy_2 = 389.0139$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 * esu_{2,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

with $fs_2 = fs = 389.0139$

with $Es_2 = Es = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 466.8167$

$fy_v = 389.0139$

$su_v = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_v = 0.4 * esu_{v,nominal} \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu_{v,nominal} = 0.08$,

considering characteristic value $fsy_v = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esu_{v,nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, 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 $f_{sv} = f_s = 389.0139$
 with $E_{sv} = E_s = 200000.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.0821349$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.0821349$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17935581$

and confined core properties:

$b = 190.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 $c = \text{confinement factor} = 1.00$
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.11286126$
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.11286126$
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.24645214$

Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.21940748$
 $Mu = MRc (4.14) = 5.7828E+008$
 $u = su (4.1) = 9.2773974E-006$

 Calculation of ratio l_b/l_d

 Inadequate Lap Length with $l_b/l_d = 0.30$

 Calculation of Mu_1 -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 9.2773974E-006$
 $Mu = 5.7828E+008$

with full section properties:

$b = 250.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00169171$
 $N = 9867.326$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.00631023$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $cu = 0.00631023$

we (5.4c) = 0.00493587

$ase = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) \cdot (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$

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).

$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

$$\text{psh},x \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00271274$$

$$\text{Lstir (Length of stirrups along Y)} = 1760.00$$

$$\text{Astir (stirrups area)} = 78.53982$$

$$\text{Asec (section area)} = 262500.00$$

$$\text{psh},y \text{ ((5.4d), TBDY)} = \text{Lstir} * \text{Astir} / (\text{Asec} * s) = 0.00351061$$

$$\text{Lstir (Length of stirrups along X)} = 1360.00$$

$$\text{Astir (stirrups area)} = 78.53982$$

$$\text{Asec (section area)} = 262500.00$$

$$s = 150.00$$

$$f_{ywe} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 466.8167$$

$$fy1 = 389.0139$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs1 = fs = 389.0139$$

$$\text{with } Es1 = Es = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 466.8167$$

$$fy2 = 389.0139$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$su2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs2 = fs = 389.0139$$

$$\text{with } Es2 = Es = 200000.00$$

$$y_v = 0.00140044$$

$$sh_v = 0.0044814$$

$$ft_v = 466.8167$$

$$fy_v = 389.0139$$

$$suv = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$suv = 0.4 * esuv_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

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.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE41-17.

$$\text{with } fsv = fs = 389.0139$$

$$\text{with } Esv = Es = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.0821349$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.0821349$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17935581$$

and confined core properties:

$$b = 190.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.21940748$$

$$M_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of M_{u2+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.2773974E-006$$

$$M_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along } Y) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

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 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 33.00$$

$$cc (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11286126$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.21940748$$

$$\mu_u = M_{Rc} (4.14) = 5.7828E+008$$

$$u = s_u (4.1) = 9.2773974E-006$$

Calculation of ratio l_b/l_d

Inadequate Lap Length with $l_b/l_d = 0.30$

Calculation of μ_{u2} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 9.2773974E-006$$

$$\mu_u = 5.7828E+008$$

with full section properties:

$$b = 250.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00169171$$

$$N = 9867.326$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.00631023$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00631023$$

$$w_e (5.4c) = 0.00493587$$

$$a_{se} = \text{Max}(((A_{conf,max} - A_{noConf})/A_{conf,max}) * (A_{conf,min}/A_{conf,max}), 0) = 0.28820848$$

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).

$$p_{sh,min} = \text{Min}(p_{sh,x}, p_{sh,y}) = 0.00271274$$

Expression ((5.4d), TBDY) for $p_{sh,min}$ has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00271274$$

$$L_{stir} (\text{Length of stirrups along } Y) = 1760.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

$$A_{sec} (\text{section area}) = 262500.00$$

$$p_{sh,y} ((5.4d), TBDY) = L_{stir} * A_{stir} / (A_{sec} * s) = 0.00351061$$

$$L_{stir} (\text{Length of stirrups along } X) = 1360.00$$

$$A_{stir} (\text{stirrups area}) = 78.53982$$

Asec (section area) = 262500.00

s = 150.00

fywe = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 466.8167

fy1 = 389.0139

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 = 389.0139

with Es1 = Es = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 466.8167

fy2 = 389.0139

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 389.0139

with Es2 = Es = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 466.8167

fyv = 389.0139

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 = 389.0139

with Esv = Es = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.0821349

2 = Asl,com/(b*d)*(fs2/fc) = 0.0821349

v = Asl,mid/(b*d)*(fsv/fc) = 0.17935581

and confined core properties:

b = 190.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 33.00

cc (5A.5, TBDY) = 0.002

c = confinement factor = 1.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.11286126

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.11286126$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.24645214$$

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->
v < v_{s,y2} - LHS eq.(4.5) is satisfied

---->
su (4.9) = 0.21940748
Mu = MRc (4.14) = 5.7828E+008
u = su (4.1) = 9.2773974E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 682046.925

Calculation of Shear Strength at edge 1, Vr1 = 682046.925

$$Vr1 = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$$

$$V_{ColO} = 682046.925$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$f_c' = 33.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$Mu = 0.36802142$$

$$Vu = 3.6540709E-008$$

$$d = 0.8*h = 600.00$$

$$Nu = 9867.326$$

$$Ag = 187500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 465424.857$$

where:

Vs1 = 116356.214 is calculated for section web, with:

$$d = 200.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.75$$

Vs2 = 349068.643 is calculated for section flange, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 150.00$$

Vs2 is multiplied by Col2 = 1.00

$$s/d = 0.25$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 572420.244$$

$$bw = 250.00$$

Calculation of Shear Strength at edge 2, Vr2 = 682046.925

$$Vr2 = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$$

$$V_{ColO} = 682046.925$$

$$knl = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) 'Vs' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$f_c' = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.36791177$

$V_u = 3.6540709E-008$

$d = 0.8 \cdot h = 600.00$

$N_u = 9867.326$

$A_g = 187500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 465424.857$

where:

$V_{s1} = 116356.214$ is calculated for section web, with:

$d = 200.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.75$

$V_{s2} = 349068.643$ is calculated for section flange, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 150.00$

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: $V_s + V_f \leq 572420.244$

$b_w = 250.00$

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, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

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

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with $I_b/I_d = 0.30$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 242154.535$
Shear Force, $V2 = 4375.009$
Shear Force, $V3 = -164.7459$
Axial Force, $F = -10541.185$
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: $A_{s,ten} = 1231.504$
-Compression: $A_{s,com} = 1231.504$
-Middle: $A_{s,mid} = 2689.203$
Mean Diameter of Tension Reinforcement, $DbL = 17.60$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.02334327$
 $u = y + p = 0.02334327$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00052964$ ((4.29), Biskinis Phd)
 $M_y = 3.9380E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 7.4354E+013$
 $factor = 0.30$
 $A_g = 262500.00$
 $fc' = 33.00$
 $N = 10541.185$
 $E_c * I_g = 2.4785E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1943307E-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 311.2112$
 $d = 707.00$
 $y = 0.31098945$
 $A = 0.02934135$
 $B = 0.01565294$
with $pt = 0.00696749$
 $pc = 0.00696749$
 $pv = 0.01521473$
 $N = 10541.185$
 $b = 250.00$
 $" = 0.06082037$
 $y_{comp} = 1.0047091E-005$
with $fc = 33.00$
 $E_c = 26999.444$
 $y = 0.30972185$
 $A = 0.02901417$
 $B = 0.01546131$
with $E_s = 200000.00$

Calculation of ratio l_b / d

Inadequate Lap Length with $l_b / d = 0.30$

- Calculation of p -

From table 10-8: $p = 0.02281363$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/l_d \geq 1$

shear control ratio $V_{yE}/V_{CoIE} = 0.56523739$

$d = 707.00$

$s = 0.00$

$t = A_v/(b_w*s) + 2*t_f/b_w*(f_{fe}/f_s) = A_v*L_{stir}/(A_g*s) + 2*t_f/b_w*(f_{fe}/f_s) = 0.00$

$A_v = 78.53982$, 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.

$NUD = 10541.185$

$A_g = 262500.00$

$f_{cE} = 33.00$

$f_{tE} = f_{yE} = 0.00$

$p_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.02914971$

$b = 250.00$

$d = 707.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column TC1 of floor 1

At local axis: 3

Integration Section: (b)