

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

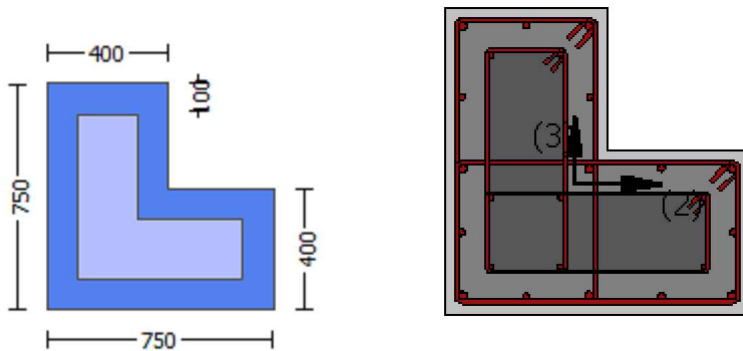
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjls

Constant Properties

Knowledge Factor, $K = 1.00$

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
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 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 400.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.22693
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = 300.00$
 No FRP Wrapping

Stepwise Properties

At local axis: 2
 EDGE -A-
 Shear Force, $V_a = -0.0001715$
 EDGE -B-
 Shear Force, $V_b = 0.0001715$
 BOTH EDGES
 Axial Force, $F = -16273.607$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 5353.274$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1137.257$
 -Compression: $A_{sl,com} = 2208.54$
 -Middle: $A_{sl,mid} = 2007.478$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.31322798$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 336755.236$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 5.0513E+008$
 $\mu_{u1+} = 2.4238E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 5.0513E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 5.0513E+008$
 $\mu_{u2+} = 2.4238E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $\mu_{u2-} = 5.0513E+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 5.2674705E-006$$

$$M_u = 2.4238E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.607$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01168357$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01168357$$

$$\phi_{ue} \text{ (5.4c)} = 0.04185674$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (\phi_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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.

$A_{conf,max1} = 353600.00$ 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 external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (\phi_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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.

$A_{conf,max2} = 171264.00$ 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 internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.0194$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.0194$$

$$\phi_{psh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.0194$$

$$\phi_{psh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

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fywe2 = 694.45
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.00426928
c = confinement factor = 1.22693
y1 = 0.00093667
sh1 = 0.00299735
ft1 = 312.2267
fy1 = 260.1889
su1 = 0.00299735
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.16409929
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, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 260.1889
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00093667
sh2 = 0.00299735
ft2 = 312.2267
fy2 = 260.1889
su2 = 0.00299735
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.16409929
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, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 260.1889
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00093667
shv = 0.00299735
ftv = 312.2267
fyv = 260.1889
suv = 0.00299735
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.16409929
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 260.1889
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.01691035
2 = Asl,com/(b*d)*(fs2/fc) = 0.03283971
v = Asl,mid/(b*d)*(fsv/fc) = 0.02985004
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.48863
cc (5A.5, TBDY) = 0.00426928
c = confinement factor = 1.22693
1 = Asl,ten/(b*d)*(fs1/fc) = 0.01919533
2 = Asl,com/(b*d)*(fs2/fc) = 0.03727712
v = Asl,mid/(b*d)*(fsv/fc) = 0.03388347
Case/Assumption: Unconfinedsd full section - Steel rupture

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satisfies Eq. (4.3)

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

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μ_u (4.9) = 0.19514753

$M_u = M_{Rc}$ (4.14) = 2.4238E+008

$u = \mu_u$ (4.1) = 5.2674705E-006

Calculation of ratio I_b/I_d

Lap Length: $I_b/I_d = 0.16409929$

$I_b = 300.00$

$I_d = 1828.161$

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

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

= 1

$d_b = 16.66667$

Mean strength value of all re-bars: $f_y = 694.45$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 1.7174$

$A_{tr} = \min(A_{tr,x}, A_{tr,y}) = 257.6106$

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

$s = \max(s_{external}, s_{internal}) = 250.00$

$n = 24.00$

Calculation of μ_{u1} -

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

$u = 5.5822518E-006$

$M_u = 5.0513E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174378$

$N = 16273.607$

$f'_c = 33.00$

ϕ (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} \cdot \max(\phi_u, \phi_c) = 0.01168357$

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

From (5.4b), TBDY: $\phi_u = 0.01168357$

we (5.4c) = 0.04185674

ϕ_{se} ((5.4d), TBDY) = $(\phi_{se1} \cdot A_{ext} + \phi_{se2} \cdot A_{int}) / A_{sec} = 0.45746528$

$\phi_{se1} = \max((A_{conf,max1} - A_{noConf1}) / A_{conf,max1} \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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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$A_{conf,max1} = 353600.00$ 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 external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{se2} (\geq \phi_{se1}) = \max(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

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,max2 = 171264.00 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 internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.0194$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.0194$

$psh1$ ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.0194$

$psh1$ ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00426928$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.00093667$

$sh1 = 0.00299735$

$ft1 = 312.2267$

$fy1 = 260.1889$

$su1 = 0.00299735$

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

$lo/lo_{min} = lb/l_d = 0.16409929$

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

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

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

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

with $fs1 = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 260.1889$

with $Es1 = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.00093667$

$sh2 = 0.00299735$

$ft2 = 312.2267$

$fy2 = 260.1889$

$su2 = 0.00299735$

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

$lo/lo_{min} = lb/l_{b,min} = 0.16409929$

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

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

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

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

$$\text{with } fs_2 = (fs_{\text{jacket}} \cdot Asl_{\text{com,jacket}} + fs_{\text{core}} \cdot Asl_{\text{com,core}}) / Asl_{\text{com}} = 260.1889$$

$$\text{with } Es_2 = (Es_{\text{jacket}} \cdot Asl_{\text{com,jacket}} + Es_{\text{core}} \cdot Asl_{\text{com,core}}) / Asl_{\text{com}} = 200000.00$$

$$y_v = 0.00093667$$

$$sh_v = 0.00299735$$

$$ft_v = 312.2267$$

$$fy_v = 260.1889$$

$$su_v = 0.00299735$$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 0.16409929$$

$$su_v = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$$
 From table 5A.1, TBDY: esuv_nominal = 0.08,
 considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
 For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
 characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
 y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl_{\text{mid,jacket}} + fs_{\text{mid}} \cdot Asl_{\text{mid,core}}) / Asl_{\text{mid}} = 260.1889$$

$$\text{with } Es_v = (Es_{\text{jacket}} \cdot Asl_{\text{mid,jacket}} + Es_{\text{mid}} \cdot Asl_{\text{mid,core}}) / Asl_{\text{mid}} = 200000.00$$

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs_1 / fc) = 0.06157447$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs_2 / fc) = 0.03170691$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.05596882$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 40.48863$$

$$cc \text{ (5A.5, TBDY)} = 0.00426928$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl_{\text{ten}} / (b \cdot d) \cdot (fs_1 / fc) = 0.07565062$$

$$2 = Asl_{\text{com}} / (b \cdot d) \cdot (fs_2 / fc) = 0.03895522$$

$$v = Asl_{\text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.0687635$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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$$su \text{ (4.9)} = 0.24053289$$

$$Mu = MRc \text{ (4.14)} = 5.0513E+008$$

$$u = su \text{ (4.1)} = 5.5822518E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.16409929$

$l_b = 300.00$

$l_d = 1828.161$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 694.45$

Mean concrete strength: $fc' = (fc'_{\text{jacket}} \cdot Area_{\text{jacket}} + fc'_{\text{core}} \cdot Area_{\text{core}}) / Area_{\text{section}} = 33.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 1.7174$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

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

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 24.00$

Calculation of Mu_{2+}

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

$$u = 5.2674705E-006$$

$$\mu = 2.4238E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.607$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01168357$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01168357$$

$$\phi_{ue} (5.4c) = 0.04185674$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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.

$A_{conf,max1} = 353600.00$ 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 external perimeter hoops.

$A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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.

$A_{conf,max2} = 171264.00$ 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 internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.0194$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 3.0194$$

$$\phi_{psh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 3.0194$$

$$\phi_{psh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00426928$
 $c = \text{confinement factor} = 1.22693$
 $y_1 = 0.00093667$
 $sh_1 = 0.00299735$
 $ft_1 = 312.2267$
 $fy_1 = 260.1889$
 $su_1 = 0.00299735$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 0.16409929$
 $su_1 = 0.4 * esu_1, nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1, nominal = 0.08$,
 For calculation of $esu_1, nominal$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 260.1889$
 with $Es_1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$
 $y_2 = 0.00093667$
 $sh_2 = 0.00299735$
 $ft_2 = 312.2267$
 $fy_2 = 260.1889$
 $su_2 = 0.00299735$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/lb, min = 0.16409929$
 $su_2 = 0.4 * esu_2, nominal ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs, jacket * Asl, com, jacket + fs, core * Asl, com, core) / Asl, com = 260.1889$
 with $Es_2 = (Es, jacket * Asl, com, jacket + Es, core * Asl, com, core) / Asl, com = 200000.00$
 $y_v = 0.00093667$
 $sh_v = 0.00299735$
 $ft_v = 312.2267$
 $fy_v = 260.1889$
 $suv = 0.00299735$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 0.16409929$
 $suv = 0.4 * esuv, nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv, nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv, nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs, jacket * Asl, mid, jacket + fs, mid * Asl, mid, core) / Asl, mid = 260.1889$
 with $Es_v = (Es, jacket * Asl, mid, jacket + Es, mid * Asl, mid, core) / Asl, mid = 200000.00$
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.01691035$
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.03283971$
 $v = Asl, mid / (b * d) * (fsv / f_c) = 0.02985004$
 and confined core properties:
 $b = 690.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.48863$
 $cc (5A.5, TBDY) = 0.00426928$
 $c = \text{confinement factor} = 1.22693$
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.01919533$
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.03727712$
 $v = Asl, mid / (b * d) * (fsv / f_c) = 0.03388347$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_s, y_2$ - LHS eq.(4.5) is satisfied
 --->
 $\mu_u(4.9) = 0.19514753$
 $\mu_u = M_{Rc}(4.14) = 2.4238E+008$
 $u = \mu_u(4.1) = 5.2674705E-006$

Calculation of ratio I_b/I_d

Lap Length: $I_b/I_d = 0.16409929$
 $I_b = 300.00$
 $I_d = 1828.161$
 Calculation of I_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 I_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 16.66667$
 Mean strength value of all re-bars: $f_y = 694.45$
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 1.7174$
 $A_{tr} = \min(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \max(s_{external}, s_{internal}) = 250.00$
 $n = 24.00$

Calculation of μ_u -

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

$u = 5.5822518E-006$
 $\mu_u = 5.0513E+008$

with full section properties:

$b = 400.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00174378$
 $N = 16273.607$
 $f'_c = 33.00$
 $\alpha_1(5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = shear_factor \cdot \max(\mu_u, \mu_c) = 0.01168357$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.01168357$
 $\mu_u(5.4c) = 0.04185674$
 $\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.45746528$
 $\alpha_{se1} = \max((A_{conf,max1} - A_{noConf1}) / A_{conf,max1} \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$
 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.
 $A_{conf,max1} = 353600.00$ 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 external perimeter hoops.
 $A_{conf,min1} = 293525.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{conf,max1}$ by a length equal to half the clear spacing between external hoops.
 $A_{noConf1} = 158733.333$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\alpha_{se2} (\geq \alpha_{se1}) = \max((A_{conf,max2} - A_{noConf2}) / A_{conf,max2} \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$
 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.

$A_{conf,max2} = 171264.00$ 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 internal perimeter hoops.

$A_{conf,min2} = 54741.00$ is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area $A_{conf,max2}$ by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.0194$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.0194$

$psh1$ ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

L_{stir1} (Length of stirrups along Y) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

L_{stir2} (Length of stirrups along Y) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.0194$

$psh1$ ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

L_{stir1} (Length of stirrups along X) = 2060.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

L_{stir2} (Length of stirrups along X) = 1468.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00426928$

c = confinement factor = 1.22693

$y1 = 0.00093667$

$sh1 = 0.00299735$

$ft1 = 312.2267$

$fy1 = 260.1889$

$su1 = 0.00299735$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/ld = 0.16409929$

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

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

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered

characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

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

with $fs1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 260.1889$

with $Es1 = (Es_{jacket} \cdot A_{sl,ten,jacket} + Es_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.00093667$

$sh2 = 0.00299735$

$ft2 = 312.2267$

$fy2 = 260.1889$

$su2 = 0.00299735$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/lb_{min} = 0.16409929$

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

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

For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered

characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

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

with $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 260.1889$

```

with Es2 = (Esjacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00093667
shv = 0.00299735
ftv = 312.2267
fyv = 260.1889
suv = 0.00299735
using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.16409929
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 260.1889
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.06157447
2 = Asl,com/(b*d)*(fs2/fc) = 0.03170691
v = Asl,mid/(b*d)*(fsv/fc) = 0.05596882
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.48863
cc (5A.5, TBDY) = 0.00426928
c = confinement factor = 1.22693
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07565062
2 = Asl,com/(b*d)*(fs2/fc) = 0.03895522
v = Asl,mid/(b*d)*(fsv/fc) = 0.0687635
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.24053289
Mu = MRc (4.14) = 5.0513E+008
u = su (4.1) = 5.5822518E-006

```

Calculation of ratio lb/ld

```

Lap Length: lb/ld = 0.16409929
lb = 300.00
ld = 1828.161
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 694.45
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 1.7174
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 24.00

```

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0751\text{E}+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0751E+006$

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

$V_{Col0} = 1.0751E+006$

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

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 1518.562$

$V_u = 0.0001715$

$d = 0.8 * h = 600.00$

$N_u = 16273.607$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 901155.609$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 802857.879$

$V_{sj1} = 279254.914$ is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{sj1} is multiplied by $Col,j1 = 1.00$

$s/d = 0.3125$

$V_{sj2} = 523602.964$ is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{sj2} is multiplied by $Col,j2 = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$

$V_{s,c1} = 0.00$ is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 98297.73$ is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$

$s/d = 0.56818182$

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

From (11-11), ACI 440: $V_s + V_f \leq 915872.391$

$bw = 400.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0751E+006$

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

$V_{Col0} = 1.0751E+006$

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

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c_jacket * Area_jacket + f'_c_core * Area_core) / Area_section = 33.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 1518.561$
 $V_u = 0.0001715$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 16273.607$
 $A_g = 300000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 901155.609$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 802857.879$
 $V_{sj1} = 279254.914$ is calculated for section web jacket, with:
 $d = 320.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.3125$
 $V_{sj2} = 523602.964$ is calculated for section flange jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.56$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.16666667$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 98297.73$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 160.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.5625$
 $V_{s,c2} = 98297.73$ is calculated for section flange core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.56818182$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 915872.391$
 $bw = 400.00$

 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1
 At local axis: 2

 Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1
 At local axis: 3
 Integration Section: (b)
 Section Type: rcjlc

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 400.00$
 Max Width, $W_{max} = 750.00$
 Min Width, $W_{min} = 400.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 959433.31$
 Shear Force, $V_2 = 9202.622$
 Shear Force, $V_3 = -247.4678$
 Axial Force, $F = -19841.972$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 5353.274$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1137.257$
 -Compression: $As_{c,com} = 2208.54$
 -Middle: $As_{mid} = 2007.478$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten,jacket} = 829.3805$
 -Compression: $As_{c,com,jacket} = 1746.726$
 -Middle: $As_{mid,jacket} = 1545.664$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten,core} = 307.8761$
 -Compression: $As_{c,com,core} = 461.8141$
 -Middle: $As_{mid,core} = 461.8141$
 Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.02802485$
 $u = y + p = 0.02802485$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00018741$ ((4.29), Biskinis Phd))
 $M_y = 2.8617E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.5270E+014$
 $factor = 0.30$
 $A_g = 440000.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 19841.972$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.0901E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

flange width, $b = 750.00$
web width, $b_w = 400.00$
flange thickness, $t = 400.00$

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 2.1216552\text{E-}006$
with $((10.1), \text{ASCE } 41-17) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/l_d)^{2/3}) = 241.538$
 $d = 707.00$
 $y = 0.19487882$
 $A = 0.01025068$
 $B = 0.00456109$
with $p_t = 0.00434791$
 $p_c = 0.00416509$
 $p_v = 0.00378591$
 $N = 19841.972$
 $b = 750.00$
 $" = 0.06082037$
 $y_{\text{comp}} = 1.6217101\text{E-}005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.1918841$
 $A = 0.01001071$
 $B = 0.00440616$
with $E_s = 200000.00$
CONFIRMATION: $y = 0.19293874 < t/d$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_d, \text{min} = 0.20512411$
 $l_b = 300.00$
 $l_d = 1462.529$
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
Mean strength value of all re-bars: $f_y = 555.56$
Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 1.7174$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 24.00$

- Calculation of p -

From table 10-8: $p = 0.02783744$

with:

- Columns controlled by inadequate development or splicing along the clear height because $l_b/l_d < 1$
shear control ratio $V_y E / C o l O E = 0.31322798$
 $d = d_{\text{external}} = 707.00$
 $s = s_{\text{external}} = 0.00$
- $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00434791$
jacket: $s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$
 $A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction
 $L_{\text{stir1}} = 2060.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s_1 = 100.00$
- core: $s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$
 $A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction
 $L_{\text{stir2}} = 1468.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s2 = 250.00$$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength. All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 19841.972$$

$$A_g = 440000.00$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 33.00$$

$$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$$

$$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot s1 + f_{y_int_Trans_Reinf} \cdot s2) / (s1 + s2) = 555.56$$

$$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.01009575$$

$$b = 750.00$$

$$d = 707.00$$

$$f_{cE} = 33.00$$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)
