

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

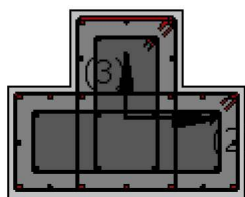
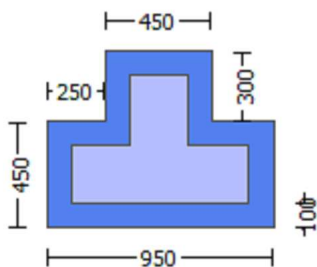
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Jacket

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, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
Concrete Elasticity, $E_c = 21019.039$
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.5556$
Existing Column
Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $E_{cc} = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.3325E+007$
Shear Force, $V_a = -4418.71$
EDGE -B-
Bending Moment, $M_b = 66724.053$
Shear Force, $V_b = 4418.71$
BOTH EDGES
Axial Force, $F = -21123.881$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1539.38$
-Compression: $A_{sl,com} = 1539.38$
-Middle: $A_{sl,mid} = 3612.832$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = \phi V_n = 1.1748E+006$
 V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoI} = 1.1748E+006$
 $V_{CoI} = 1.1748E+006$
 $k_n l = 1.00$
displacement_ductility_demand = 0.00734998

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

= 1 (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 20.80$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 3.96802$

$\mu_u = 1.3325E+007$

$V_u = 4418.71$

$d = 0.8 \cdot h = 760.00$

$N_u = 21123.881$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 976155.669$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 879645.943$

$V_{sj1} = 282743.339$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{sj2} = 596902.604$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 96509.726$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 96509.726$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.0362E+006$

$bw = 450.00$

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 $\theta = 3.2182844E-005$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00437863$ ((4.29), Biskinis Phd)

$M_y = 1.1430E+009$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3015.694

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6241E+014$

factor = 0.30

$A_g = 562500.00$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$

$N = 21123.881$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 8.7468E+014$

Calculation of Yielding Moment M_y

Calculation of δ and M_y according to Annex 7 -

```
y = Min( y_ten, y_com)
y_ten = 3.9309396E-006
with fy = 529.9948
d = 907.00
y = 0.25674483
A = 0.01649259
B = 0.00868375
with pt = 0.0037716
pc = 0.0037716
pv = 0.00885172
N = 21123.881
b = 450.00
" = 0.04740904
y_comp = 9.4783751E-006
with fc = 33.00
Ec = 26999.444
y = 0.25591187
A = 0.01627731
B = 0.0085861
with Es = 200000.00
```

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

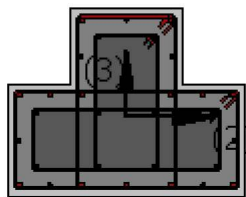
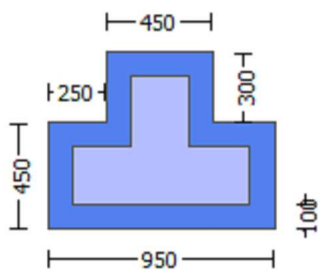
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

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Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22442

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -0.00043816$

EDGE -B-

Shear Force, $V_b = 0.00043816$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1539.38$
 -Compression: $As_{c,com} = 2475.575$
 -Middle: $As_{mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.20669$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$
 with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.9795E+009$
 $Mu_{1+} = 1.8303E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 1.9795E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.9795E+009$
 $Mu_{2+} = 1.8303E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{2-} = 1.9795E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 5.2038205E-005$
 $M_u = 1.8303E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$
 $f_c = 33.00$
 $\phi_c (5A.5, TBDY) = 0.002$

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$

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

From (5.4b), TBDY: $\phi_u = 0.01139045$

we (5.4c) = 0.03891204

$\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$

$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\phi_{ase2} (>= \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

Shear_factor = 1.00

$lo/lo_{min} = lb/ld = 1.00$

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

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

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

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

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 791.8782$

$fy2 = 659.8985$

$su2 = 0.032$

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

$lo/lo_{min} = lb/lb_{min} = 1.00$

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

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

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

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

with $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 659.8985$

with $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

```

shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
    c = confinement factor = 1.22442
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
    2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005

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Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

u = 6.4195365E-005
Mu = 1.9795E+009

with full section properties:

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b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204

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$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$$

$$psh1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$$

$$psh1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 791.8782$$

$$fy1 = 659.8985$$

$$su1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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, ASCE 41-17.

$$\text{with } fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 659.8985$$

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867
Mu = MRc (4.15) = 1.9795E+009
u = su (4.1) = 6.4195365E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

$$u = 5.2038205E-005$$

$$Mu = 1.8303E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01139045$$

$$w_e (5.4c) = 0.03891204$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2560.00$$

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

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424424$$

```

c = confinement factor = 1.22442
y1 = 0.0025
sh1 = 0.008
ft1 = 800.00
fy1 = 666.6667
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 791.8782
fy2 = 659.8985
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 659.8985
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

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

```

u = 6.4195365E-005
Mu = 1.9795E+009

```

with full section properties:

```

b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.031
fc = 33.00

```

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01139045

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

From (5.4b), TBDY: cu = 0.01139045

we (5.4c) = 0.03891204

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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,max1 = 464100.00 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.

Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to bi2/6 as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to bi2/6 as defined at (A.2).

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.40577

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.40577

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.87305
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 791.8782

fy1 = 659.8985

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1555992$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09774821$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.16889827$
 and confined core properties:
 $b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.18749341$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11778432$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.20351848$
 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
 --->

$su (4.8) = 0.29493867$
 $\mu_u = M_{Rc} (4.15) = 1.9795E+009$
 $u = su (4.1) = 6.4195365E-005$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.0936E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0936E+006$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 1.0936E+006$
 $knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1122.249$
 $V_u = 0.00043816$
 $d = 0.8 * h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col_{j2} = 1.00$

$s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 930841.148$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 1.0936E+006$
 $knl = 1$ (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: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1122.249$
 $V_u = 0.00043816$
 $d = 0.8 * h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$

s = 250.00
Vs,c2 is multiplied by Col,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Jacket
New material: Steel Strength, $f_s = 1.25*f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25*f_{sm} = 555.5556$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $E_{cc} = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.22442
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 2.6259672E-008$
EDGE -B-
Shear Force, $V_b = -2.6259672E-008$

BOTH EDGES

Axial Force, $F = -20792.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{c,com} = 1539.38$

-Middle: $As_{mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.06395$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.4457E+009$

$Mu_{1+} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.4457E+009$

$Mu_{2+} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 4.6992200E-005$

$M_u = 2.4457E+009$

with full section properties:

$b = 450.00$

$d = 907.00$

$d' = 43.00$

$\nu = 0.0015437$

$N = 20792.031$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$

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

From (5.4b), TBDY: $\phi_u = 0.01139045$

we (5.4c) = 0.03891204

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2$ ($\geq ase1$) = $\text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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,max2 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.40577

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.40577

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.87305

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982

psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345

Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

$f_{tv} = 790.7246$
 $f_{yv} = 658.9372$
 $s_{uv} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
 considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv_nominal}$ and y_v , sh_v, f_{tv}, f_{yv} , it is considered
 characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 658.9372$
 with $E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.07619403$
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.07619403$
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.17674942$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.09092359$
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.09092359$
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.21091798$

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
 --->
 $su (4.8) = 0.2492127$
 $Mu = MR_c (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_1 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 4.6992200E-005$
 $Mu = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 $w_e (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.53375773$

$$ase1 = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}})/A_{\text{conf,max1}}) * (A_{\text{conf,min1}}/A_{\text{conf,max1}}), 0) = 0.53375773$$

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.

$A_{\text{conf,max1}} = 464100.00$ 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.

$A_{\text{conf,min1}} = 395025.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max1}}$ by a length equal to half the clear spacing between external hoops.

$A_{\text{noConf1}} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}})/A_{\text{conf,max2}}) * (A_{\text{conf,min2}}/A_{\text{conf,max2}}), 0) = 0.53375773$$

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.

$A_{\text{conf,max2}} = 252164.00$ 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.

$A_{\text{conf,min2}} = 111441.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max2}}$ by a length equal to half the clear spacing between internal hoops.

$A_{\text{noConf2}} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{\text{min}} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ (5.4d)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ ((5.4d), TBDY)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{\text{sec}} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 800.00$$

$$fy1 = 666.6667$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 666.6667$$

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

$$y2 = 0.0025$$

```

sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu2+

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

$$\phi_u = 4.6992200E-005$$

$$\mu = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

$$\phi_0 (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_0) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.01139045$$

$$\phi_{ue} (5.4c) = 0.03891204$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.40577$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.40577$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.87305$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$\phi_{psh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00424424$$

$$\phi_c = \text{confinement factor} = 1.22442$$

```

y1 = 0.0025
sh1 = 0.008
ft1 = 800.00
fy1 = 666.6667
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->

```


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

---->

$$s_u(4.8) = 0.2492127$$

$$M_u = M_{Rc}(4.15) = 2.4457E+009$$

$$u = s_u(4.1) = 4.6992200E-005$$

Calculation of ratio I_b/I_d

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

Calculation of M_{u2} -

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

$$u = 4.6992200E-005$$

$$M_u = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.01139045$$

$$\phi_w(5.4c) = 0.03891204$$

$$\phi_{se}((5.4d), \text{TB DY}) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{se2} (\geq \phi_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{sh,min} * \phi_{ywe} = \text{Min}(\phi_{sh,x} * \phi_{ywe}, \phi_{sh,y} * \phi_{ywe}) = 2.40577$$

$$\phi_{sh,x} * \phi_{ywe} = \phi_{sh1} * \phi_{ywe1} + \phi_{sh2} * \phi_{ywe2} = 2.40577$$

$$\phi_{sh1}((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

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

$$\phi_{sh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

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

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.87305$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$Asec = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.4444$

$fywe2 = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

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

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

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_jacket \cdot Asl, ten, jacket + fs_core \cdot Asl, ten, core) / Asl, ten = 666.6667$

with $Es1 = (Es_jacket \cdot Asl, ten, jacket + Es_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

$fy2 = 666.6667$

$su2 = 0.032$

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

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

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

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.

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_jacket \cdot Asl, com, jacket + fs_core \cdot Asl, com, core) / Asl, com = 666.6667$

with $Es2 = (Es_jacket \cdot Asl, com, jacket + Es_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 790.7246$

$fyv = 658.9372$

$suv = 0.032$

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

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

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

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 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, ASCE 41-17.

with $fsv = (fs_jacket \cdot Asl, mid, jacket + fs_mid \cdot Asl, mid, core) / Asl, mid = 658.9372$

with $Es_v = (Es_jacket \cdot Asl, mid, jacket + Es_mid \cdot Asl, mid, core) / Asl, mid = 200000.00$

$1 = Asl, ten / (b \cdot d) \cdot (fs1 / f_{ce}) = 0.07619403$

$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07619403$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17674942$
 and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09092359$
 $2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09092359$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21091798$
 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
 --->
 $su (4.8) = 0.2492127$
 $\mu_u = M_{Rc} (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.5325E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325E+006$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 1.5325E+006$
 $k_{nl} = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.80319424$
 $V_u = 2.6259672E-008$
 $d = 0.8 * h = 760.00$
 $N_u = 20792.031$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$
 $V_{sj1} = 314159.265$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 663225.116$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 0.41666667$$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325E+006$

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

$$V_{Col0} = 1.5325E+006$$

$knl = 1$ (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: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 0.80417674$$

$$V_u = 2.6259672E-008$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.031$$

$$A_g = 427500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.0846E+006$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977384.381$$

$V_{s,j1} = 314159.265$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$
 $bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $Ecc = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 20039.74$
Shear Force, $V_2 = -4418.71$
Shear Force, $V_3 = -9.33613$
Axial Force, $F = -21123.881$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1539.38$
-Compression: $As_{l,com} = 2475.575$
-Middle: $As_{l,mid} = 2676.637$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{l,ten,jacket} = 1231.504$
-Compression: $As_{l,com,jacket} = 1859.823$

-Middle: $Asl_{mid,jacket} = 2060.885$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten,core} = 307.8761$
 -Compression: $Asl_{com,core} = 615.7522$
 -Middle: $Asl_{mid,core} = 615.7522$
 Mean Diameter of Tension Reinforcement, $DbL = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \frac{1}{2} u = 0.00525736$
 $u = y + p = 0.00525736$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00342745$ ((4.29), Biskinis Phd))
 $M_y = 8.3069E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 2146.471
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7341E+014$
 $factor = 0.30$
 $A_g = 562500.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21123.881$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7803E+014$

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, $b = 950.00$
 web width, $b_w = 450.00$
 flange thickness, $t = 450.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.6828434E-006$
 with $f_y = 529.9948$
 $d = 707.00$
 $y = 0.19958991$
 $A = 0.01002226$
 $B = 0.00468923$
 with $p_t = 0.00229194$
 $p_c = 0.00368581$
 $p_v = 0.00398517$
 $N = 21123.881$
 $b = 950.00$
 $" = 0.06082037$
 $y_{comp} = 1.5661897E-005$
 with $fc = 33.00$
 $E_c = 26999.444$
 $y = 0.19868626$
 $A = 0.00989144$
 $B = 0.00462988$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19958991 < t/d$

Calculation of ratio l_b/d

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

- Calculation of p -

From table 10-8: $p = 0.00182991$

with:

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

shear control ratio $V_{yE}/V_{CoIE} = 1.20669$

$d = d_{\text{external}} = 707.00$

$s = s_{\text{external}} = 0.00$

- $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.0035764$

jacket: $s_1 = A_{v1} \cdot L_{\text{stir1}}/(s_1 \cdot A_g) = 0.00301593$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot L_{\text{stir2}}/(s_2 \cdot A_g) = 0.00056047$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1568.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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

where $f = 2 \cdot t_f/bw$ 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.

$N_{UD} = 21123.881$

$A_g = 562500.00$

$f_{cE} = (f_{c_jacket} \cdot A_{\text{jacket}} + f_{c_core} \cdot A_{\text{core}})/\text{section_area} = 26.93333$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot A_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot A_{\text{int_Long_Reinf}})/A_{\text{Tot_Long_Rein}} = 529.9948$

$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2)/(s_1 + s_2) = 538.1429$

$p_l = A_{\text{Tot_Long_Rein}}/(b \cdot d) = 0.00996292$

$b = 950.00$

$d = 707.00$

$f_{cE} = 26.93333$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

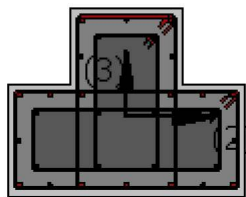
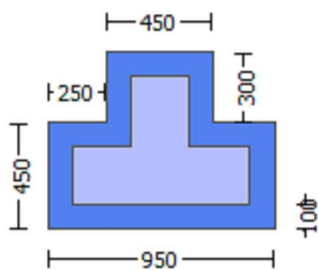
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Jacket

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, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

New material: Steel Strength, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 20039.74$
 Shear Force, $V_a = -9.33613$
 EDGE -B-
 Bending Moment, $M_b = 8447.268$
 Shear Force, $V_b = 9.33613$
 BOTH EDGES
 Axial Force, $F = -21123.881$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{sc,com} = 2475.575$
 -Middle: $A_{sc,mid} = 2676.637$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 992466.902$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{ColO} = 992466.902$
 $V_{Col} = 992466.902$
 $k_n = 1.00$
 displacement_ductility_demand = 0.00186425

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

= 1 (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 20.80$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 3.57745$
 $M_u = 20039.74$
 $V_u = 9.33613$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 21123.881$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 824756.036$
 where:
 $V_{s,jacket} = V_{sj1} + V_{sj2} = 753982.237$
 $V_{sj1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 282743.339$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{sc1} + V_{sc2} = 70773.799$
 $V_{sc1} = 70773.799$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 V_{sc1} is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{sc2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 818016.733$
 $bw = 450.00$

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 $\theta = 6.3896466E-006$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00342745 ((4.29), Biskinis Phd)$
 $M_y = 8.3069E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 2146.471
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7341E+014$
 $factor = 0.30$
 $A_g = 562500.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21123.881$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 5.7803E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:
flange width, $b = 950.00$
web width, $bw = 450.00$
flange thickness, $t = 450.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.6828434E-006$
with $f_y = 529.9948$
 $d = 707.00$
 $y = 0.19958991$
 $A = 0.01002226$
 $B = 0.00468923$
with $pt = 0.00229194$
 $pc = 0.00368581$
 $pv = 0.00398517$
 $N = 21123.881$
 $b = 950.00$
 $" = 0.06082037$
 $y_{comp} = 1.5661897E-005$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19868626$
 $A = 0.00989144$
 $B = 0.00462988$
with $E_s = 200000.00$
CONFIRMATION: $y = 0.19958991 < t/d$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

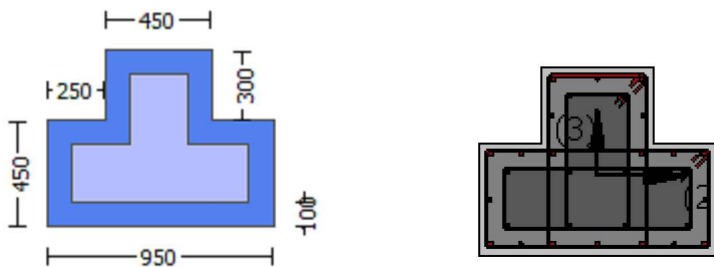
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_r)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $Ecc = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.22442
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -0.00043816$
 EDGE -B-
 Shear Force, $V_b = 0.00043816$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1539.38$
 -Compression: $As_{l,com} = 2475.575$
 -Middle: $As_{l,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.20669$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.9795E+009$
 $\mu_{u1+} = 1.8303E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 1.9795E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.9795E+009$
 $\mu_{u2+} = 1.8303E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $\mu_{u2-} = 1.9795E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 5.2038205E-005$
 $M_u = 1.8303E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$

$f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of α : $\alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\alpha = 0.01139045$
 $w_e (5.4c) = 0.03891204$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.
 $A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.4444$
 $f_{ywe2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5.A5), TBDY), TBDY: $\alpha_c = 0.00424424$
 α_c = confinement factor = 1.22442
 $\gamma_1 = 0.0025$
 $\delta_1 = 0.008$
 $f_{t1} = 800.00$
 $f_{y1} = 666.6667$
 $\alpha_{s1} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $l_o / l_{ou,min} = l_b / l_d = 1.00$
 $\alpha_{s1} = 0.4 * \alpha_{s1,nominal} ((5.5), TBDY) = 0.032$

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 $fs1 = (fs_jacket \cdot Asl_ten_jacket + fs_core \cdot Asl_ten_core) / Asl_ten = 666.6667$
with $Es1 = (Es_jacket \cdot Asl_ten_jacket + Es_core \cdot Asl_ten_core) / Asl_ten = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 791.8782$
 $fy2 = 659.8985$
 $su2 = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu2_nominal = 0.08$,
For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs2 = (fs_jacket \cdot Asl_com_jacket + fs_core \cdot Asl_com_core) / Asl_com = 659.8985$
with $Es2 = (Es_jacket \cdot Asl_com_jacket + Es_core \cdot Asl_com_core) / Asl_com = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 794.9922$
 $fyv = 662.4935$
 $suv = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_nominal = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_jacket \cdot Asl_mid_jacket + fs_mid \cdot Asl_mid_core) / Asl_mid = 662.4935$
with $Es_v = (Es_jacket \cdot Asl_mid_jacket + Es_mid \cdot Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.04630179$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.07370488$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.08000444$
and confined core properties:
 $b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 fcc (5A.2, TBDY) = 40.40598
 cc (5A.5, TBDY) = 0.00424424
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05161335$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.08216003$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.08918226$
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) = 0.13022232
 $Mu = MRc$ (4.15) = 1.8303E+009
 $u = su$ (4.1) = 5.2038205E-005

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 6.4195365E-005$$

$$\mu_u = 1.9795E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.031$$

$$f_c = 33.00$$

$$\alpha_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_u: \mu_u = \text{shear_factor} * \text{Max}(\mu_u, \alpha_0) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01139045$$

$$\mu_{ue} \text{ (5.4c)} = 0.03891204$$

$$\mu_{se} \text{ ((5.4d), TBDY)} = (\mu_{se1} * A_{ext} + \mu_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\mu_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{se2} (\geq \mu_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$s1 = 100.00$
 $s2 = 250.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5A.5), TBDY), TBDY: $cc = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 791.8782$
 $fy1 = 659.8985$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs_{jacket} * Asl, \text{ten}, \text{jacket} + fs_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 659.8985$
 with $Es1 = (Es_{jacket} * Asl, \text{ten}, \text{jacket} + Es_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 800.00$
 $fy2 = 666.6667$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = (fs_{jacket} * Asl, \text{com}, \text{jacket} + fs_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 666.6667$
 with $Es2 = (Es_{jacket} * Asl, \text{com}, \text{jacket} + Es_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 794.9922$
 $fyv = 662.4935$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl, \text{mid}, \text{jacket} + fs_{mid} * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 662.4935$
 with $Es_v = (Es_{jacket} * Asl, \text{mid}, \text{jacket} + Es_{mid} * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / f_c) = 0.1555992$
 $2 = Asl, \text{com} / (b * d) * (fs2 / f_c) = 0.09774821$
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.16889827$
 and confined core properties:
 $b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / f_c) = 0.18749341$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11778432$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.20351848$$

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

---->

$$s_u(4.8) = 0.29493867$$

$$M_u = M_{Rc}(4.15) = 1.9795E+009$$

$$u = s_u(4.1) = 6.4195365E-005$$

Calculation of ratio l_b/d

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

Calculation of M_{u2+}

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

$$u = 5.2038205E-005$$

$$M_u = 1.8303E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha_c, \alpha_s) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \alpha_c = 0.01139045$$

$$\alpha_s(5.4c) = 0.03891204$$

$$\alpha_{se}((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\alpha_{se2}(\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.40577$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$
 $Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 (5.4d) = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$
 $Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$Asec = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$
 $c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 800.00$
 $fy1 = 666.6667$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = (fs_jacket * Asl, \text{ten}, \text{jacket} + fs_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 666.6667$

with $Es1 = (Es_jacket * Asl, \text{ten}, \text{jacket} + Es_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 791.8782$
 $fy2 = 659.8985$
 $su2 = 0.032$

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

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

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

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

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

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_jacket * Asl, \text{com}, \text{jacket} + fs_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 659.8985$

with $Es2 = (Es_jacket * Asl, \text{com}, \text{jacket} + Es_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 794.9922$
 $fyv = 662.4935$
 $suv = 0.032$

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

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

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

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

considering characteristic value $f_{sv} = f_{sv}/1.2$, 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, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 662.4935$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04630179$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07370488$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08000444$

and confined core properties:

$b = 890.00$

$d = 677.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 40.40598

cc (5A.5, TBDY) = 0.00424424

c = confinement factor = 1.22442

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05161335$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08216003$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08918226$

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) = 0.13022232

$Mu = MRc$ (4.15) = 1.8303E+009

$u = su$ (4.1) = 5.2038205E-005

Calculation of ratio l_b/l_d

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

Calculation of Mu_2 -

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

$u = 6.4195365E-005$

$Mu = 1.9795E+009$

with full section properties:

$b = 450.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00198039$

$N = 20792.031$

$f_c = 33.00$

co (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01139045$

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

From (5.4b), TBDY: $cu = 0.01139045$

we (5.4c) = 0.03891204

ase ((5.4d), TBDY) = $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.53375773$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i/6$ as defined at (A.2).
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i/6$ as defined at (A.2).
 $psh,min * F_{ywe} = \text{Min}(psh,x * F_{ywe}, psh,y * F_{ywe}) = 2.40577$

 $psh,x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$
 $psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2 ((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

 $psh,y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$
 $psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 791.8782$

$fy1 = 659.8985$

$su1 = 0.032$

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

Shear_factor = 1.00

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

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

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, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 659.8985$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

$fy2 = 666.6667$

$su2 = 0.032$

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

Shear_factor = 1.00

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

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

From table 5A.1, TBDY: $es_{2_nominal} = 0.08$,
 For calculation of $es_{2_nominal}$ 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, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 666.6667$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 794.9922$
 $fy_v = 662.4935$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou_{min} = lb/d = 1.00$
 $suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$
 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, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 662.4935$
 with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.1555992$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.09774821$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.16889827$

and confined core properties:

$b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.18749341$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.11778432$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.20351848$

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

--->
 $su (4.8) = 0.29493867$
 $\mu_u = MR_c (4.15) = 1.9795E+009$
 $u = su (4.1) = 6.4195365E-005$

 Calculation of ratio lb/d

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

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0936E+006$

 Calculation of Shear Strength at edge 1, $V_{r1} = 1.0936E+006$

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

$V_{Col0} = 1.0936E+006$

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

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

 $= 1$ (normal-weight concrete)
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $fc'^{0.5} \leq$

8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 1122.249$$

$$V_u = 0.00043816$$

$$d = 0.8 \cdot h = 600.00$$

$$N_u = 20792.031$$

$$A_g = 337500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 916395.596$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$$

$V_{sj1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$V_{sj2} = 314159.265$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$$V_{s,c1} \text{ is multiplied by } Col,c1 = 1.00$$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$$V_{s,c2} \text{ is multiplied by } Col,c2 = 0.00$$

$$s/d = 1.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 930841.148$$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936E+006$

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

$$V_{Col0} = 1.0936E+006$$

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

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

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

$$\text{Mean concrete strength: } f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 26.93333, \text{ but } f_c'^{0.5} \leq$$

8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 1122.249$$

$$V_u = 0.00043816$$

$$d = 0.8 \cdot h = 600.00$$

$$N_u = 20792.031$$

$$A_g = 337500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 916395.596$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$$

$V_{sj1} = 523598.776$ is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

```

fy = 555.5556
s = 100.00
Vs,j1 is multiplied by Col,j1 = 1.00
s/d = 0.16666667
Vs,j2 = 314159.265 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.5556
s = 100.00
Vs,j2 is multiplied by Col,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 78637.555
Vs,c1 = 78637.555 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs,c1 is multiplied by Col,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs,c2 is multiplied by Col,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 930841.148
bw = 450.00

```

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $Ecc = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.22442
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 2
 EDGE -A-
 Shear Force, $V_a = 2.6259672E-008$
 EDGE -B-
 Shear Force, $V_b = -2.6259672E-008$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1539.38$
 -Compression: $As_{c,com} = 1539.38$
 -Middle: $As_{mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.06395$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 2.4457E+009$
 $\mu_{u1+} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 2.4457E+009$
 $\mu_{u2+} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $\mu_{u2-} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 4.6992200E-005$
 $\mu_u = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $\nu = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$

$co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 $we (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.53375773$
 $ase1 = Max(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.53375773$
 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.
 $Aconf,max1 = 464100.00$ 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.
 $Aconf,min1 = 395025.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $Aconf,max1$ by a length equal to half the clear spacing between external hoops.
 $AnoConf1 = 173066.667$ is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).
 $ase2 (>= ase1) = Max(((Aconf,max2 - AnoConf2) / Aconf,max2) * (Aconf,min2 / Aconf,max2), 0) = 0.53375773$
 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.
 $Aconf,max2 = 252164.00$ 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.
 $Aconf,min2 = 111441.00$ 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.
 $AnoConf2 = 110709.333$ is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).
 $psh,min * Fywe = Min(psh,x * Fywe, psh,y * Fywe) = 2.40577$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.40577$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$
 $Lstir1$ (Length of stirrups along Y) = 2160.00
 $Astir1$ (stirrups area) = 78.53982
 $psh2 (5.4d) = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$
 $Lstir2$ (Length of stirrups along Y) = 1568.00
 $Astir2$ (stirrups area) = 50.26548

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 $Lstir1$ (Length of stirrups along X) = 2560.00
 $Astir1$ (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 $Lstir2$ (Length of stirrups along X) = 1968.00
 $Astir2$ (stirrups area) = 50.26548

$Asec = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$
 From ((5.A5), TBDY), TBDY: $cc = 0.00424424$
 $c =$ confinement factor = 1.22442
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 800.00$
 $fy1 = 666.6667$
 $su1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00
 $lo/lou,min = lb/d = 1.00$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,

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

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

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 800.00$
 $fy2 = 666.6667$
 $su2 = 0.032$

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

$lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$

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

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

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

with $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667$

with $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 790.7246$
 $fyv = 658.9372$
 $suv = 0.032$

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

$lo/lou,min = lb/ld = 1.00$
 $suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$

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

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

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

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

with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372$

with $Es_v = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$

$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798$

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
 --->
 $su (4.8) = 0.2492127$
 $Mu = MRc (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio lb/ld

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

Calculation of Mu1-

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

$$\mu = 4.6992200E-005$$

$$Mu = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01139045$$

$$w_e \text{ (5.4c)} = 0.03891204$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$s_2 = 250.00$
 $fy_{we1} = 694.4444$
 $fy_{we2} = 555.5556$
 $f_{ce} = 33.00$
 From ((5A.5), TBDY), TBDY: $cc = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 800.00$
 $fy_1 = 666.6667$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,
 For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 666.6667$
 with $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 800.00$
 $fy_2 = 666.6667$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/lb, \min = 1.00$
 $su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,
 For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 666.6667$
 with $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 790.7246$
 $fy_v = 658.9372$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou, \min = lb/ld = 1.00$
 $suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$
 From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, 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_v, sh_v, ft_v, fy_v , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 658.9372$
 with $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.07619403$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.07619403$
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.17674942$
 and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 40.40598$
 $cc (5A.5, \text{TBDY}) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.09092359$
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.09092359$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21091798$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

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

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

--->
 $\mu_u (4.8) = 0.2492127$
 $\mu_u = M_{Rc} (4.15) = 2.4457E+009$
 $u = \mu_u (4.1) = 4.6992200E-005$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u2+}

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

$u = 4.6992200E-005$
 $\mu_u = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$

$f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.01139045$
The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.01139045$

$\mu_{ue} (5.4c) = 0.03891204$

$\mu_{ase} ((5.4d), TBDY) = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.53375773$

$\mu_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$\mu_{ase2} (\geq \mu_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 2.40577$

$\mu_{psh,x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$
 $Lstir1$ (Length of stirrups along Y) = 2160.00
 $Astir1$ (stirrups area) = 78.53982
 $psh2 (5.4d) = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$
 $Lstir2$ (Length of stirrups along Y) = 1568.00
 $Astir2$ (stirrups area) = 50.26548

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 $Lstir1$ (Length of stirrups along X) = 2560.00
 $Astir1$ (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 $Lstir2$ (Length of stirrups along X) = 1968.00
 $Astir2$ (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 790.7246

fyv = 658.9372

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

For calculation of $\epsilon_{suv_nominal}$ and γ_v , Δv , Δf_v , Δf_{yv} , it is considered characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

γ_1 , Δf_1 , Δf_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 658.9372$

with $\epsilon_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.07619403$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.07619403$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.17674942$

and confined core properties:

$b = 390.00$

$d = 877.00$

$d' = 13.00$

$f_{cc} \text{ (5A.2, TBDY)} = 40.40598$

$cc \text{ (5A.5, TBDY)} = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.09092359$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.09092359$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.21091798$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$\mu_u \text{ (4.8)} = 0.2492127$

$\mu_u = M_{Rc} \text{ (4.15)} = 2.4457E+009$

$u = \mu_u \text{ (4.1)} = 4.6992200E-005$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 4.6992200E-005$

$\mu_u = 2.4457E+009$

with full section properties:

$b = 450.00$

$d = 907.00$

$d' = 43.00$

$v = 0.0015437$

$N = 20792.031$

$f_c = 33.00$

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

Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.01139045$

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

From (5.4b), TBDY: $\mu_u = 0.01139045$

$w_e \text{ (5.4c)} = 0.03891204$

$\alpha_{se} \text{ ((5.4d), TBDY)} = (\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.53375773$

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (>=ase1) = \text{Max}(((A_{conf,max2}-AnoConf2)/A_{conf,max2})*(A_{conf,min2}/A_{conf,max2}),0) = 0.53375773$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.40577$

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.40577$

$psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593$

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

$psh2 ((5.4d)) = Lstir2*Astir2/(Asec*s2) = 0.00056047$

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.87305$

$psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443$

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345$

Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

For calculation of $es_{u2_nominal}$ and y_2 , sh_2 , ft_2 , fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 666.6667$

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

$y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 790.7246$
 $fy_v = 658.9372$
 $suv = 0.032$

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

$lo/lou_{min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot es_{u_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{u_nominal} = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{u_nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 658.9372$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.07619403$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.07619403$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.17674942$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.09092359$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.09092359$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.21091798$

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
 --->
 $su (4.8) = 0.2492127$
 $Mu = MRc (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.5325E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325E+006$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 1.5325E+006$
 $knl = 1$ (zero step-static loading)

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

= 1 (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$
 $\mu = 0.80319424$
 $V_u = 2.6259672E+008$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 20792.031$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$
 $V_{sj1} = 314159.265$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 663225.116$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 107233.029$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325E+006$
 $V_{r2} = V_{col} ((10.3), ASCE 41-17) = knl \cdot V_{col0}$
 $V_{col0} = 1.5325E+006$
 $knl = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu = 0.80417674$
 $V_u = 2.6259672E+008$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 20792.031$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$
 $V_{sj1} = 314159.265$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$

$s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 107233.029$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$
 $bw = 450.00$

 End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
 At local axis: 3
 Integration Section: (a)
 Section Type: rcjtcs

Constant Properties

 Knowledge Factor, $= 1.00$
 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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 Steel Elasticity, $E_s = 200000.00$
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $E_{cc} = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars

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

Stepwise Properties

Bending Moment, $M = -1.3325 \times 10^7$
Shear Force, $V_2 = -4418.71$
Shear Force, $V_3 = -9.33613$
Axial Force, $F = -21123.881$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1539.38$
-Compression: $A_{sl,com} = 1539.38$
-Middle: $A_{sl,mid} = 3612.832$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,jacket} = 1231.504$
-Compression: $A_{sl,com,jacket} = 1231.504$
-Middle: $A_{sl,mid,jacket} = 2689.203$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,core} = 307.8761$
-Compression: $A_{sl,com,core} = 307.8761$
-Middle: $A_{sl,mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.00676725$
 $u = y + p = 0.00676725$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00437863$ ((4.29), Biskinis Phd))
 $M_y = 1.1430 \times 10^9$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3015.694
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.6241 \times 10^{14}$
factor = 0.30
 $A_g = 562500.00$
Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21123.881$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.7468 \times 10^{14}$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 3.9309396 \times 10^{-6}$
with $f_y = 529.9948$
 $d = 907.00$
 $y = 0.25674483$
 $A = 0.01649259$
 $B = 0.00868375$
with $pt = 0.0037716$
 $pc = 0.0037716$
 $p_v = 0.00885172$
 $N = 21123.881$
 $b = 450.00$

" = 0.04740904
y_comp = 9.4783751E-006
with fc = 33.00
Ec = 26999.444
y = 0.25591187
A = 0.01627731
B = 0.0085861
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.00238862

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio $V_yE/V_{ColOE} = 1.06395$

d = d_external = 907.00

s = s_external = 0.00

- t = $s_1 + s_2 + 2*tf/bw*(ffe/fs) = 0.00427788$

jacket: $s_1 = Av_1*Lstir_1/(s_1*Ag) = 0.00357443$

Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction

Lstir1 = 2560.00, is the total Length of all stirrups parallel to loading (shear) direction

s1 = 100.00

core: $s_2 = Av_2*Lstir_2/(s_2*Ag) = 0.00070345$

Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction

Lstir2 = 1968.00, is the total Length of all stirrups parallel to loading (shear) direction

s2 = 250.00

The term $2*tf/bw*(ffe/fs)$ is implemented to account for FRP contribution

where $f = 2*tf/bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

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

For the normalisation fs of jacket is used.

NUD = 21123.881

Ag = 562500.00

f_{cE} = (fc_jacket*Area_jacket+ fc_core*Area_core)/section_area = 26.93333

f_{yE} = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+ fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 529.9948

f_{ytE} = (fy_ext_Trans_Reinf* s1+fy_int_Trans_Reinf* s2)/(s1+ s2) = 537.2846

pl = Area_Tot_Long_Rein/(b*d) = 0.01639493

b = 450.00

d = 907.00

f_{cE} = 26.93333

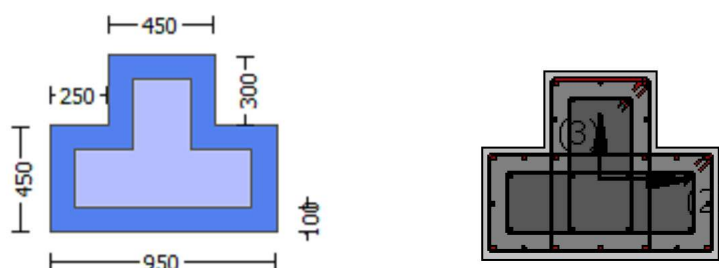
End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

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



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
 At local axis: 2
 Integration Section: (b)
 Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
 Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
 Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 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, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$
 Concrete Elasticity, $E_c = 21019.039$
 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, ASCE 41-17) because bending is considered as
 Deformation-Controlled Action (Table C7-1, ASCE 41-17).
 Jacket
 New material: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material: Steel Strength, $f_s = f_{sm} = 555.5556$
 Existing Column
 Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $Ecc = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$

Element Length, L = 3000.00
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -1.3325E+007$
 Shear Force, $V_a = -4418.71$
 EDGE -B-
 Bending Moment, $M_b = 66724.053$
 Shear Force, $V_b = 4418.71$
 BOTH EDGES
 Axial Force, $F = -21123.881$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{sc,com} = 1539.38$
 -Middle: $A_{st,mid} = 3612.832$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 1.3703E+006$
 V_n ((10.3), ASCE 41-17) = $k_n l V_{CoI} = 1.3703E+006$
 $V_{CoI} = 1.3703E+006$
 $k_n l = 1.00$
 displacement_ductility_demand = 0.01765288

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: $f'_c = (f'_{c,jacket} \text{Area}_{jacket} + f'_{c,core} \text{Area}_{core}) / \text{Area}_{section} = 20.80$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 2.00$
 $M_u = 66724.053$
 $V_u = 4418.71$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 21123.881$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 976155.669$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 879645.943$
 $V_{sj1} = 282743.339$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj1} is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 596902.604$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj2} is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 96509.726$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 96509.726$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.0362E+006$
 $bw = 450.00$

displacement_ductility_demand is calculated as ϕ_y

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

From analysis, chord rotation $\theta = 7.6893207E-006$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00043558 ((4.29), Biskinis Phd)$
 $M_y = 1.1430E+009$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.6241E+014$
 $factor = 0.30$
 $A_g = 562500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21123.881$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 8.7468E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

$y = \min(\phi_{y,ten}, \phi_{y,com})$
 $\phi_{y,ten} = 3.9309396E-006$
 with $f_y = 529.9948$
 $d = 907.00$
 $y = 0.25674483$
 $A = 0.01649259$
 $B = 0.00868375$
 with $p_t = 0.0037716$
 $p_c = 0.0037716$
 $p_v = 0.00885172$
 $N = 21123.881$
 $b = 450.00$
 $\phi_{y,comp} = 9.4783751E-006$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.25591187$
 $A = 0.01627731$
 $B = 0.0085861$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 6

column C1, Floor 1

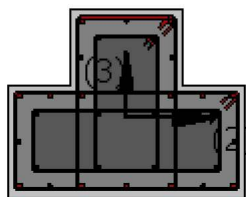
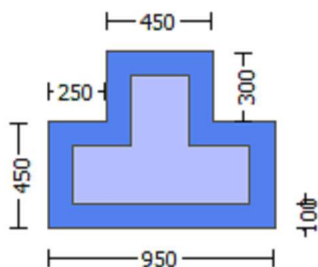
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjctcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$ 
Existing Column
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$ 
#####
Max Height,  $H_{max} = 750.00$ 
Min Height,  $H_{min} = 450.00$ 
Max Width,  $W_{max} = 950.00$ 
Min Width,  $W_{min} = 450.00$ 
Eccentricity,  $Ecc = 250.00$ 
Jacket Thickness,  $t_j = 100.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.22442
Element Length,  $L = 3000.00$ 
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} \geq 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -0.00043816$ 
EDGE -B-
Shear Force,  $V_b = 0.00043816$ 
BOTH EDGES
Axial Force,  $F = -20792.031$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $A_{st} = 0.00$ 
  -Compression:  $A_{sc} = 6691.592$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $A_{st,ten} = 1539.38$ 
  -Compression:  $A_{st,com} = 2475.575$ 
  -Middle:  $A_{st,mid} = 2676.637$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.20669$ 
Member Controlled by Shear ( $V_e/V_r > 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$ 
with
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.9795E+009$ 
 $\mu_{1+} = 1.8303E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{1-} = 1.9795E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.9795E+009$ 
 $\mu_{2+} = 1.8303E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{2-} = 1.9795E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

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

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:
 $\mu = 5.2038205E-005$ 
 $M_u = 1.8303E+009$ 

```

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear_factor} * \text{Max}(\alpha, \alpha_c) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \alpha = 0.01139045$$

$$\alpha_e (5.4c) = 0.03891204$$

$$\alpha_{se} ((5.4d), \text{TB DY}) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\alpha_{se2} (> \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.40577$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.87305$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$p_{sh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.00424424$$

$$\alpha = \text{confinement factor} = 1.22442$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 800.00$$

```

fy1 = 666.6667
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 791.8782
fy2 = 659.8985
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 659.8985
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
    c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232

```

$$\begin{aligned} \mu_u &= M/R_c(4.15) = 1.8303E+009 \\ u &= s_u(4.1) = 5.2038205E-005 \end{aligned}$$

Calculation of ratio I_b/I_d

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

Calculation of μ_{u1} -

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

$$\begin{aligned} u &= 6.4195365E-005 \\ \mu_u &= 1.9795E+009 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 450.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00198039 \\ N &= 20792.031 \\ f_c &= 33.00 \end{aligned}$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01139045$$

$$w_e(5.4c) = 0.03891204$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

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

$$p_{sh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

Lstir1 (Length of stirrups along X) = 2560.00
 Astir1 (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 Lstir2 (Length of stirrups along X) = 1968.00
 Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 791.8782

fy1 = 659.8985

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992

2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821

v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827

and confined core properties:

```

b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867
Mu = MRc (4.15) = 1.9795E+009
u = su (4.1) = 6.4195365E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 5.2038205E-005
Mu = 1.8303E+009

with full section properties:

```

b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
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,max1 = 464100.00 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.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to bi2/6 as defined at (A.2).
ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773
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 = 252164.00 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.40577$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d)) = L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.87305$

$psh1 ((5.4d), TBDY) = L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/l_d = 1.00$

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

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

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

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

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

with $fs1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 791.8782$

$fy2 = 659.8985$

$su2 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$lo/lo_{min} = lb/l_{b,min} = 1.00$

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

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

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

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

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

with $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 659.8985$

with $Es2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$


```

suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuvnominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuvnominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuvnominal 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 = (fsjacket*Aslmid,jacket + fsmid*Aslmid,core)/Aslmid = 662.4935
with Esv = (Esjacket*Aslmid,jacket + Esmid*Aslmid,core)/Aslmid = 200000.00
1 = Aslten/(b*d)*(fs1/fc) = 0.04630179
2 = Aslcom/(b*d)*(fs2/fc) = 0.07370488
v = Aslmid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Aslten/(b*d)*(fs1/fc) = 0.05161335
2 = Aslcom/(b*d)*(fs2/fc) = 0.08216003
v = Aslmid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005
-----

Calculation of ratio lb/ld
-----
Adequate Lap Length: lb/ld >= 1
-----
-----
Calculation of Mu2-
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 6.4195365E-005
Mu = 1.9795E+009
-----
with full section properties:
b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

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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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.40577$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.87305$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 791.8782$

$fy1 = 659.8985$

$su1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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 $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 659.8985$

with $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

```

fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867
Mu = MRc (4.15) = 1.9795E+009
u = su (4.1) = 6.4195365E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0936E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0936E+006$

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

VColO = 1.0936E+006

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 1122.249$

$V_u = 0.00043816$

$d = 0.8 \cdot h = 600.00$

$N_u = 20792.031$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 916395.596$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 837758.041$

$V_{s,j1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 314159.265$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.27777778$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 930841.148$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936\text{E}+006$

$V_{r2} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = knl \cdot V_{\text{ColO}}$

$V_{\text{ColO}} = 1.0936\text{E}+006$

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 1122.249$

$V_u = 0.00043816$

$d = 0.8 \cdot h = 600.00$

$N_u = 20792.031$

$A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 916395.596$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837758.041$
 $V_{s,j1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 930841.148$
 $bw = 450.00$

 End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At local axis: 3

 Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
 At Shear local axis: 2
 (Bending local axis: 3)
 Section Type: rcjtcs

Constant Properties

 Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 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

```

Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$ 
Existing Column
Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$ 
#####
Max Height,  $H_{max} = 750.00$ 
Min Height,  $H_{min} = 450.00$ 
Max Width,  $W_{max} = 950.00$ 
Min Width,  $W_{min} = 450.00$ 
Eccentricity,  $Ecc = 250.00$ 
Jacket Thickness,  $t_j = 100.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.22442
Element Length,  $L = 3000.00$ 
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} > 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force,  $V_a = 2.6259672E-008$ 
EDGE -B-
Shear Force,  $V_b = -2.6259672E-008$ 
BOTH EDGES
Axial Force,  $F = -20792.031$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $A_{st} = 0.00$ 
  -Compression:  $A_{sc} = 6691.592$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $A_{st,ten} = 1539.38$ 
  -Compression:  $A_{st,com} = 1539.38$ 
  -Middle:  $A_{st,mid} = 3612.832$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.06395$ 
Member Controlled by Shear ( $V_e/V_r > 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$ 
with
 $M_{pr1} = \text{Max}(\mu_{1+} , \mu_{1-}) = 2.4457E+009$ 
 $\mu_{1+} = 2.4457E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{1-} = 2.4457E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{2+} , \mu_{2-}) = 2.4457E+009$ 
 $\mu_{2+} = 2.4457E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{2-} = 2.4457E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination
-----

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

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:
 $\mu = 4.6992200E-005$ 
 $\mu_u = 2.4457E+009$ 
-----

```

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi: \phi = \text{shear_factor} * \text{Max}(\phi, \alpha) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.01139045$$

$$\phi_e (5.4c) = 0.03891204$$

$$\phi_e ((5.4d), \text{TB DY}) = (\phi_1 * A_{ext} + \phi_2 * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_2 (> \phi_1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{sh,min} * \phi_{ywe} = \text{Min}(\phi_{sh,x} * \phi_{ywe}, \phi_{sh,y} * \phi_{ywe}) = 2.40577$$

$$\phi_{sh,x} * \phi_{ywe} = \phi_{sh1} * \phi_{ywe1} + \phi_{sh2} * \phi_{ywe2} = 2.40577$$

$$\phi_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\phi_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\phi_{sh,y} * \phi_{ywe} = \phi_{sh1} * \phi_{ywe1} + \phi_{sh2} * \phi_{ywe2} = 2.87305$$

$$\phi_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$\phi_{sh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.00424424$$

$$\alpha = \text{confinement factor} = 1.22442$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 800.00$$

$$fy_1 = 666.6667$$

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009

```


$$u = su(4.1) = 4.6992200E-005$$

Calculation of ratio lb/d

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

Calculation of $Mu1$ -

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

$$u = 4.6992200E-005$$

$$Mu = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01139045$$

$$we(5.4c) = 0.03891204$$

$$ase((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.53375773$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.53375773$$

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.

$Aconf,max1 = 464100.00$ 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.

$Aconf,min1 = 395025.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $Aconf,max1$ by a length equal to half the clear spacing between external hoops.

$AnoConf1 = 173066.667$ is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((Aconf,max2 - AnoConf2) / Aconf,max2) * (Aconf,min2 / Aconf,max2), 0) = 0.53375773$$

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.

$Aconf,max2 = 252164.00$ 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.

$Aconf,min2 = 111441.00$ 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.

$AnoConf2 = 110709.333$ is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.40577$$

$$psh,x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.40577$$

$$psh1((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

$$Lstir1 (\text{Length of stirrups along Y}) = 2160.00$$

$$Astir1 (\text{stirrups area}) = 78.53982$$

$$psh2(5.4d) = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

$$Lstir2 (\text{Length of stirrups along Y}) = 1568.00$$

$$Astir2 (\text{stirrups area}) = 50.26548$$

$$psh,y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305$$

$$psh1((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

$$Lstir1 (\text{Length of stirrups along X}) = 2560.00$$

Astir1 (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 Lstir2 (Length of stirrups along X) = 1968.00
 Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

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

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 790.7246

fyv = 658.9372

suv = 0.032

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

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403

2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403

v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942

and confined core properties:

b = 390.00

$d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09092359$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09092359$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21091798$
 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
 --->

$su (4.8) = 0.2492127$
 $\mu_u = M_{Rc} (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/d

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

Calculation of μ_{u2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 4.6992200E-005$
 $\mu_u = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 $w_e (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.40577$

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.40577$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1*Astir1/(Asec*s1) = 0.00301593$
 $Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ (5.4d)} = Lstir2*Astir2/(Asec*s2) = 0.00056047$
 $Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.87305$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1*Astir1/(Asec*s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2*Astir2/(Asec*s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$Asec = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$
 $c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 800.00$
 $fy1 = 666.6667$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 800.00$
 $fy2 = 666.6667$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667$

with $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 790.7246$
 $fyv = 658.9372$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 658.9372$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07619403$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07619403$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.17674942$
and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09092359$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.09092359$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.21091798$
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
--->
 $su (4.8) = 0.2492127$
 $Mu = MRc (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 4.6992200E-005$
 $Mu = 2.4457E+009$

with full section properties:
 $b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.01139045$
 $we (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.53375773$
 $ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

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

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

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, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

$fy2 = 666.6667$

```

su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.5325\text{E}+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325\text{E}+006$

$V_{r1} = V_{CoI} ((10.3), \text{ASCE } 41-17) = knl * V_{CoI0}$

$V_{CoI0} = 1.5325\text{E}+006$

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

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

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c \text{ jacket} \cdot \text{Area jacket} + f'_c \text{ core} \cdot \text{Area core}) / \text{Area section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.80319424$

$V_u = 2.6259672 \text{E-}008$

$d = 0.8 \cdot h = 760.00$

$N_u = 20792.031$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.0846 \text{E+}006$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977384.381$

$V_{s,j1} = 314159.265$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col,j1} = 1.00$

$s/d = 0.27777778$

$V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col,j2} = 1.00$

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1791 \text{E+}006$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325 \text{E+}006$

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

$V_{\text{ColO}} = 1.5325 \text{E+}006$

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

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

= 1 (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_c \text{ jacket} \cdot \text{Area jacket} + f'_c \text{ core} \cdot \text{Area core}) / \text{Area section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.80417674$

$V_u = 2.6259672 \text{E-}008$

$d = 0.8 \cdot h = 760.00$

$N_u = 20792.031$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.0846E+006$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977384.381$

$V_{s,j1} = 314159.265$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $= 1.00$

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$
 Eccentricity, $Ecc = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 8447.268$
 Shear Force, $V_2 = 4418.71$
 Shear Force, $V_3 = 9.33613$
 Axial Force, $F = -21123.881$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{ten} = 1539.38$
 -Compression: $As_{com} = 2475.575$
 -Middle: $As_{mid} = 2676.637$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{ten,jacket} = 1231.504$
 -Compression: $As_{com,jacket} = 1859.823$
 -Middle: $As_{mid,jacket} = 2060.885$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{ten,core} = 307.8761$
 -Compression: $As_{com,core} = 615.7522$
 -Middle: $As_{mid,core} = 615.7522$
 Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{R} = u = 0.00327467$
 $u = y + p = 0.00327467$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00144476$ ((4.29), Biskinis Phd))
 $M_y = 8.3069E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 904.793
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7341E+014$
 $factor = 0.30$
 $A_g = 562500.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21123.881$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 5.7803E+014$

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, $b = 950.00$
 web width, $bw = 450.00$
 flange thickness, $t = 450.00$

```

y = Min( y_ten, y_com)
y_ten = 4.6828434E-006
with fy = 529.9948
d = 707.00
y = 0.19958991
A = 0.01002226
B = 0.00468923
with pt = 0.00229194
pc = 0.00368581
pv = 0.00398517
N = 21123.881
b = 950.00
" = 0.06082037
y_comp = 1.5661897E-005
with fc = 33.00
Ec = 26999.444
y = 0.19868626
A = 0.00989144
B = 0.00462988
with Es = 200000.00
CONFIRMATION: y = 0.19958991 < t/d

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

- Calculation of p -

From table 10-8: p = 0.00182991

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1

shear control ratio $V_yE/V_{col}E = 1.20669$

d = d_external = 707.00

s = s_external = 0.00

- $t = s_1 + s_2 + 2*tf/bw*(ffe/fs) = 0.0035764$

jacket: $s_1 = A_{v1}*L_{stir1}/(s_1*Ag) = 0.00301593$

Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction

Lstir1 = 2160.00, is the total Length of all stirrups parallel to loading (shear) direction

s1 = 100.00

core: $s_2 = A_{v2}*L_{stir2}/(s_2*Ag) = 0.00056047$

Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction

Lstir2 = 1568.00, is the total Length of all stirrups parallel to loading (shear) direction

s2 = 250.00

The term $2*tf/bw*(ffe/fs)$ is implemented to account for FRP contribution

where $f = 2*tf/bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

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

For the normalisation fs of jacket is used.

NUD = 21123.881

Ag = 562500.00

f_{cE} = (f_{c_jacket}*Area_{jacket}+ f_{c_core}*Area_{core})/section_area = 26.93333

f_{yE} = (f_{y_ext_Long_Reinf}*Area_{ext_Long_Reinf}+ f_{y_int_Long_Reinf}*Area_{int_Long_Reinf})/Area_{Tot_Long_Rein} = 529.9948

f_{yE} = (f_{y_ext_Trans_Reinf}* s₁+ f_{y_int_Trans_Reinf}* s₂)/(s₁+ s₂) = 538.1429

pl = Area_{Tot_Long_Rein}/(b*d) = 0.00996292

b = 950.00

d = 707.00

f_{cE} = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

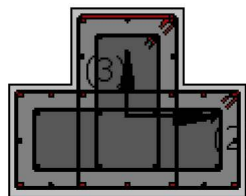
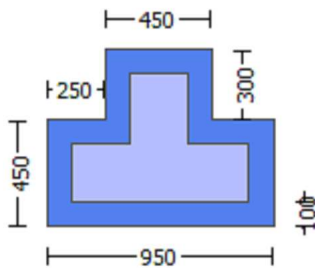
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Jacket

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, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

New material: Steel Strength, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $Ecc = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 20039.74$
 Shear Force, $V_a = -9.33613$
 EDGE -B-
 Bending Moment, $M_b = 8447.268$
 Shear Force, $V_b = 9.33613$
 BOTH EDGES
 Axial Force, $F = -21123.881$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{st,com} = 2475.575$
 -Middle: $A_{st,mid} = 2676.637$
 Mean Diameter of Tension Reinforcement, $D_{bL,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 1.1301E+006$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 1.1301E+006$
 $V_{CoI} = 1.1301E+006$
 $k_n = 1.00$
 displacement_ductility_demand = $1.4445924E-005$

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

= 1 (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 20.80$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 2.00$
 $M_u = 8447.268$
 $V_u = 9.33613$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 21123.881$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 824756.036$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 753982.237$
 $V_{sj1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$

$s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$
 $V_{s,c1} = 70773.799$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 818016.733$
 $bw = 450.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END B -
 for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 2.0870900E-008$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00144476 ((4.29), Biskinis Phd)$
 $M_y = 8.3069E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 904.793
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7341E+014$
 $factor = 0.30$
 $A_g = 562500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21123.881$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 5.7803E+014$

Calculation of Yielding Moment M_y

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

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:
 flange width, $b = 950.00$
 web width, $bw = 450.00$
 flange thickness, $t = 450.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.6828434E-006$
 with $f_y = 529.9948$
 $d = 707.00$
 $y = 0.19958991$
 $A = 0.01002226$
 $B = 0.00468923$
 with $pt = 0.00229194$
 $pc = 0.00368581$

$p_v = 0.00398517$
 $N = 21123.881$
 $b = 950.00$
 $" = 0.06082037$
 $y_{comp} = 1.5661897E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19868626$
 $A = 0.00989144$
 $B = 0.00462988$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19958991 < t/d$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 8

column C1, Floor 1

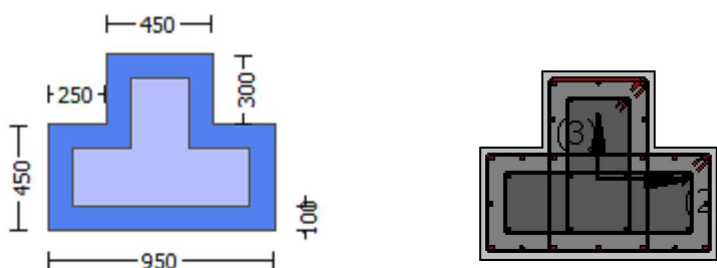
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
 Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
 Concrete Elasticity, $E_c = 21019.039$
 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
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
 Existing Column
 Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$
 #####
 Max Height, $H_{max} = 750.00$
 Min Height, $H_{min} = 450.00$
 Max Width, $W_{max} = 950.00$
 Min Width, $W_{min} = 450.00$
 Eccentricity, $E_{cc} = 250.00$
 Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.22442
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -0.00043816$
 EDGE -B-
 Shear Force, $V_b = 0.00043816$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{st,com} = 2475.575$
 -Middle: $A_{st,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.20669$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$
 with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.9795E+009$
 $M_{u1+} = 1.8303E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination

Mu1- = 1.9795E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.9795E+009
Mu2+ = 1.8303E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
Mu2- = 1.9795E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu1+

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

$$\phi_u = 5.2038205E-005$$

$$M_u = 1.8303E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01139045$$

$$\phi_{we} (5.4c) = 0.03891204$$

$$\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (\geq \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.40577$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.40577$$

$$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.87305$$

$$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

Astir1 (stirrups area) = 78.53982
 psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
 Lstir2 (Length of stirrups along X) = 1968.00
 Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

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

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 791.8782

fy2 = 659.8985

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 659.8985

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

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

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179

2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488

v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444

and confined core properties:

b = 890.00

$d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05161335$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08216003$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08918226$
 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
 --->

$s_u (4.8) = 0.13022232$
 $\mu_u = M_{Rc} (4.15) = 1.8303E+009$
 $u = s_u (4.1) = 5.2038205E-005$

Calculation of ratio l_b/d

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

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.4195365E-005$
 $\mu_u = 1.9795E+009$

with full section properties:

$b = 450.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00198039$
 $N = 20792.031$
 $f_c = 33.00$
 $cc (5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u = \text{shear_factor} * \text{Max}(\mu_u, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.01139045$
 $w_e (5.4c) = 0.03891204$
 $a_{se} ((5.4d), TBDY) = (a_{se1}*A_{ext}+a_{se2}*A_{int})/A_{sec} = 0.53375773$
 $a_{se1} = \text{Max}(((A_{conf,max1}-A_{noConf1})/A_{conf,max1})*(A_{conf,min1}/A_{conf,max1}),0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2})*(A_{conf,min2}/A_{conf,max2}),0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.40577$

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.40577$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1*Astir1/(Asec*s1) = 0.00301593$
 $Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ (5.4d)} = Lstir2*Astir2/(Asec*s2) = 0.00056047$
 $Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.87305$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1*Astir1/(Asec*s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2*Astir2/(Asec*s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$Asec = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$
 $c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 791.8782$
 $fy1 = 659.8985$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 800.00$
 $fy2 = 666.6667$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667$

with $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 794.9922$
 $fyv = 662.4935$
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 662.4935$
with $Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.1555992$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.09774821$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.16889827$

and confined core properties:

$b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.18749341$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.11778432$
 $v = A_{sl,mid} / (b * d) * (fsv / f_c) = 0.20351848$

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

--->
 $su (4.8) = 0.29493867$
 $Mu = MRc (4.15) = 1.9795E+009$
 $u = su (4.1) = 6.4195365E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_{2+}

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

$u = 5.2038205E-005$
 $Mu = 1.8303E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.01139045$
 $we (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.53375773$
 $ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

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

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

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, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 791.8782$

$fy2 = 659.8985$

```

su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 659.8985
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 6.4195365E-005

Mu = 1.9795E+009

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01139045$$

$$we(5.4c) = 0.03891204$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$$

$$psh1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$psh2(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$$

$$psh1((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$psh2((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 791.8782$$


```

fy1 = 659.8985
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
    c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867

```

$$\begin{aligned} \mu &= MRC(4.15) = 1.9795E+009 \\ u &= su(4.1) = 6.4195365E-005 \end{aligned}$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.0936E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0936E+006$

$V_{r1} = V_{col}((10.3), ASCE 41-17) = k_n l * V_{col0}$

$V_{col0} = 1.0936E+006$

$k_n l = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 26.93333$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 1122.249$

$\nu_u = 0.00043816$

$d = 0.8 * h = 600.00$

$N_u = 20792.031$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$

$V_{sj1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{sj2} = 314159.265$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 930841.148$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936E+006$

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

$V_{Col0} = 1.0936E+006$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 4.00$

$\mu_u = 1122.249$

$V_u = 0.00043816$

$d = 0.8 * h = 600.00$

$N_u = 20792.031$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$

$V_{sj1} = 523598.776$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{sj2} = 314159.265$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 930841.148$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
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
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$
Existing Column
Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $E_{cc} = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.22442
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} \geq 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = 2.6259672E-008$
EDGE -B-
Shear Force, $V_b = -2.6259672E-008$
BOTH EDGES
Axial Force, $F = -20792.031$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1539.38$
-Compression: $A_{st,com} = 1539.38$
-Middle: $A_{st,mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.06395$
Member Controlled by Shear ($V_e/V_r > 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.4457E+009$
 $M_{u1+} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment

direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.4457\text{E}+009$$

$M_{u2+} = 2.4457\text{E}+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 2.4457\text{E}+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$$\phi_u = 4.6992200\text{E}-005$$

$$M_u = 2.4457\text{E}+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$\nu = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.01139045$$

$$\phi_{we} (5.4c) = 0.03891204$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2} (>= \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.40577$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.40577$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\phi_{ps2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.87305$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
 Lstir2 (Length of stirrups along X) = 1968.00
 Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 790.7246

fyv = 658.9372

suv = 0.032

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

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403

2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403

v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942

and confined core properties:

b = 390.00

d = 877.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09092359$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09092359$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21091798$
 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
 --->
 $su (4.8) = 0.2492127$
 $Mu = MRc (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/l_d

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

Calculation of $Mu1$ -

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

$u = 4.6992200E-005$
 $Mu = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 $we (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.53375773$
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.40577$

 $psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.40577$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1*Astir1/(Asec*s1) = 0.00301593$
 $Lstir1 \text{ (Length of stirrups along Y)} = 2160.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ (5.4d)} = Lstir2*Astir2/(Asec*s2) = 0.00056047$
 $Lstir2 \text{ (Length of stirrups along Y)} = 1568.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

 $psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.87305$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1*Astir1/(Asec*s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2*Astir2/(Asec*s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

 $Asec = 562500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 694.4444$
 $fywe2 = 555.5556$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$
 $c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 800.00$
 $fy1 = 666.6667$
 $su1 = 0.032$

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

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

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

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

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

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

with $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667$

with $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 800.00$
 $fy2 = 666.6667$
 $su2 = 0.032$

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

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

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

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

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

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

with $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667$

with $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$
 $shv = 0.008$
 $ftv = 790.7246$
 $fyv = 658.9372$
 $suv = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv , shv , ftv , fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1$, $sh1$, $ft1$, $fy1$, are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 658.9372$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.07619403$
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.07619403$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.17674942$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 fcc (5A.2, TBDY) = 40.40598
 cc (5A.5, TBDY) = 0.00424424
 c = confinement factor = 1.22442
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.09092359$
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.09092359$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.21091798$

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) = 0.2492127
 $Mu = MRc$ (4.15) = 2.4457E+009
 $u = su$ (4.1) = 4.6992200E-005

Calculation of ratio l_b/l_d

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

Calculation of $Mu2+$

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

$u = 4.6992200E-005$
 $Mu = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $fc = 33.00$
 co (5A.5, TBDY) = 0.002
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 we (5.4c) = 0.03891204
 ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$
 $ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.

$A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.

$A_{noconf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noconf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noconf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$

 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.40577$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.87305$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

 $A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

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

$su1 = 0.4 * esu1_{nominal}$ ((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, ASCE 41-17.

with $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

$fy2 = 666.6667$

$su2 = 0.032$

```

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2-

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

u = 4.6992200E-005

Mu = 2.4457E+009

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \alpha) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.01139045$$

$$\phi_e \text{ (5.4c)} = 0.03891204$$

$$\phi_{se} \text{ ((5.4d), TB DY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{se2} (> \phi_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{sh,min} * \phi_{ywe} = \text{Min}(\phi_{sh,x} * \phi_{ywe}, \phi_{sh,y} * \phi_{ywe}) = 2.40577$$

$$\phi_{sh,x} * \phi_{ywe} = \phi_{sh1} * \phi_{ywe1} + \phi_{sh2} * \phi_{ywe2} = 2.40577$$

$$\phi_{sh1} \text{ ((5.4d), TB DY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$\phi_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$\phi_{sh,y} * \phi_{ywe} = \phi_{sh1} * \phi_{ywe1} + \phi_{sh2} * \phi_{ywe2} = 2.87305$$

$$\phi_{sh1} \text{ ((5.4d), TB DY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$\phi_{sh2} \text{ ((5.4d), TB DY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$\phi_{ywe1} = 694.4444$$

$$\phi_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.00424424$$

$$\alpha = \text{confinement factor} = 1.22442$$

$$\gamma_1 = 0.0025$$

$$\gamma_{sh} = 0.008$$

$$f_{t1} = 800.00$$

$$\phi_{y1} = 666.6667$$

```

su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009

```

$$u = su(4.1) = 4.6992200E-005$$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.5325E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325E+006$

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

$V_{Col0} = 1.5325E+006$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3 \text{ MPa}$ (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.80319424$

$\nu_u = 2.6259672E-008$

$d = 0.8 * h = 760.00$

$N_u = 20792.031$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$

$V_{sj1} = 314159.265$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{sj1} is multiplied by $Col_{j1} = 1.00$

$s/d = 0.27777778$

$V_{sj2} = 663225.116$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

V_{sj2} is multiplied by $Col_{j2} = 1.00$

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325E+006$

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

VCol0 = 1.5325E+006

knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 0.80417674$

$V_u = 2.6259672E+008$

$d = 0.8 \cdot h = 760.00$

$N_u = 20792.031$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 1.0846E+006$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 977384.381$

$V_{s,j1} = 314159.265$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.27777778$

$V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.13157895$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 107233.029$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $Ecc = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d > 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 66724.053$
Shear Force, $V_2 = 4418.71$
Shear Force, $V_3 = 9.33613$
Axial Force, $F = -21123.881$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1539.38$
-Compression: $As_{c,com} = 1539.38$
-Middle: $As_{mid} = 3612.832$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 1231.504$
-Compression: $As_{c,com,jacket} = 1231.504$
-Middle: $As_{mid,jacket} = 2689.203$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 307.8761$
-Compression: $As_{c,com,core} = 307.8761$
-Middle: $As_{mid,core} = 923.6282$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.00282421$
 $u = y + p = 0.00282421$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00043558$ ((4.29), Biskinis Phd))
 $M_y = 1.1430E+009$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.6241E+014$
factor = 0.30

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 26.93333$$

$$N = 21123.881$$

$$E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 8.7468 \text{E}+014$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 3.9309396 \text{E}-006$$

$$\text{with } f_y = 529.9948$$

$$d = 907.00$$

$$y = 0.25674483$$

$$A = 0.01649259$$

$$B = 0.00868375$$

$$\text{with } p_t = 0.0037716$$

$$p_c = 0.0037716$$

$$p_v = 0.00885172$$

$$N = 21123.881$$

$$b = 450.00$$

$$" = 0.04740904$$

$$y_{\text{comp}} = 9.4783751 \text{E}-006$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.25591187$$

$$A = 0.01627731$$

$$B = 0.0085861$$

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

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.00238862$

with:

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

shear control ratio $V_y E / V_{CoI} E = 1.06395$

$$d = d_{\text{external}} = 907.00$$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00427788$$

$$\text{jacket: } s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00357443$$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2560.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00070345$$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1968.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

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.

$$N_{UD} = 21123.881$$

$$A_g = 562500.00$$

$$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 26.93333$$

$$f_{yIE} = (f_{y_{\text{ext_Long_Reinf}}} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_{y_{\text{int_Long_Reinf}}} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 529.9948$$

$$f_{yIE} = (f_{y_{\text{ext_Trans_Reinf}}} \cdot s_1 + f_{y_{\text{int_Trans_Reinf}}} \cdot s_2) / (s_1 + s_2) = 537.2846$$

$$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01639493$$

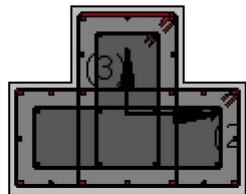
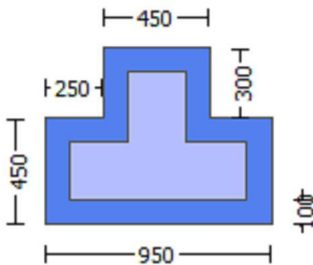
$$b = 450.00$$

d = 907.00
f_{cE} = 26.93333

End Of Calculation of Chord Rotation Capacity for element: column JTC1 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 VR_d
Edge: Start
Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
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, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, $f_c = f_{cm} = 33.00$
New material: Steel Strength, $f_s = f_{sm} = 555.5556$
Existing Column
Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $Ecc = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -1.6572E+007$
Shear Force, $V_a = -5495.352$
EDGE -B-
Bending Moment, $M_b = 82981.529$
Shear Force, $V_b = 5495.352$
BOTH EDGES
Axial Force, $F = -21204.738$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{l,ten} = 1539.38$
-Compression: $As_{l,com} = 1539.38$
-Middle: $As_{l,mid} = 3612.832$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = *V_n = 1.1748E+006$
 V_n ((10.3), ASCE 41-17) = $knI * V_{CoIO} = 1.1748E+006$
 $V_{CoI} = 1.1748E+006$
 $knI = 1.00$
displacement_ductility_demand = 0.00914062

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: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 20.80$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 3.96802$
 $M_u = 1.6572E+007$
 $V_u = 5495.352$

$d = 0.8 \cdot h = 760.00$
 $Nu = 21204.738$
 $Ag = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 976155.669$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 879645.943$
 $V_{s,j1} = 282743.339$ is calculated for section web jacket, with:
 $d = 360.00$
 $Av = 157079.633$
 $fy = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{s,j2} = 596902.604$ is calculated for section flange jacket, with:
 $d = 760.00$
 $Av = 157079.633$
 $fy = 500.00$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 96509.726$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $Av = 100530.965$
 $fy = 400.00$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 96509.726$ is calculated for section flange core, with:
 $d = 600.00$
 $Av = 100530.965$
 $fy = 400.00$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.0362E+006$
 $bw = 450.00$

displacement_ductility_demand is calculated as δ_u / y

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

From analysis, chord rotation $\theta = 4.0024370E-005$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00437874 ((4.29), Biskinis Phd)$
 $M_y = 1.1430E+009$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3015.694
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6241E+014$
 $factor = 0.30$
 $Ag = 562500.00$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$
 $N = 21204.738$
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 8.7468E+014$

Calculation of Yielding Moment M_y

Calculation of δ_u and M_y according to Annex 7 -

$y = \min(\delta_{u,ten}, \delta_{u,com})$
 $\delta_{u,ten} = 3.9309683E-006$
 with $fy = 529.9948$
 $d = 907.00$

$y = 0.25675026$
 $A = 0.01649296$
 $B = 0.00868413$
 with $pt = 0.0037716$
 $pc = 0.0037716$
 $pv = 0.00885172$
 $N = 21204.738$
 $b = 450.00$
 $" = 0.04740904$
 $y_{comp} = 9.4782912E-006$
 with $fc = 33.00$
 $E_c = 26999.444$
 $y = 0.25591414$
 $A = 0.01627686$
 $B = 0.0085861$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

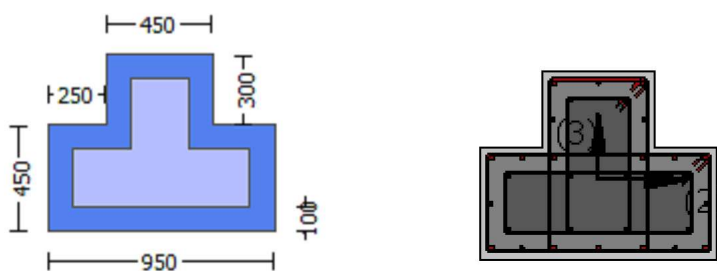
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22442

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -0.00043816$

EDGE -B-

Shear Force, $V_b = 0.00043816$

BOTH EDGES

Axial Force, $F = -20792.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{l,com} = 2475.575$

-Middle: $As_{l,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.20669$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$

with
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.9795E+009$
 $\mu_{1+} = 1.8303E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{1-} = 1.9795E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.9795E+009$
 $\mu_{2+} = 1.8303E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{2-} = 1.9795E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

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

$$\mu = 5.2038205E-005$$

$$M_u = 1.8303E+009$$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$
 $f_c = 33.00$
 $\phi_c (5A.5, \text{TB DY}) = 0.002$
Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.01139045$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TB DY: $\phi_c = 0.01139045$
 $w_e (5.4c) = 0.03891204$
 $a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
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.
 $A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.
 $A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.40577$
 $p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00
 A_{stir1} (stirrups area) = 78.53982
 $p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

$Asec = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.4444$

$fywe2 = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

$c = \text{confinement factor} = 1.22442$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

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

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

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

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

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

with $fs1 = (fs_jacket * A_{sl, ten, jacket} + fs_core * A_{sl, ten, core}) / A_{sl, ten} = 666.6667$

with $Es1 = (Es_jacket * A_{sl, ten, jacket} + Es_core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 791.8782$

$fy2 = 659.8985$

$su2 = 0.032$

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

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

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

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

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

$y2, sh2, ft2, fy2$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs2 = (fs_jacket * A_{sl, com, jacket} + fs_core * A_{sl, com, core}) / A_{sl, com} = 659.8985$

with $Es2 = (Es_jacket * A_{sl, com, jacket} + Es_core * A_{sl, com, core}) / A_{sl, com} = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 794.9922$

$fyv = 662.4935$

$suv = 0.032$

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

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

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

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 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, ASCE 41-17.

with $fsv = (fs_jacket * A_{sl, mid, jacket} + fs_mid * A_{sl, mid, core}) / A_{sl, mid} = 662.4935$

with $Esv = (Es_jacket * A_{sl, mid, jacket} + Es_mid * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$

$1 = A_{sl, ten} / (b * d) * (fs1 / f_{ce}) = 0.04630179$

$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07370488$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08000444$
 and confined core properties:
 $b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.05161335$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.08216003$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08918226$
 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
 --->
 $su (4.8) = 0.13022232$
 $Mu = MRc (4.15) = 1.8303E+009$
 $u = su (4.1) = 5.2038205E-005$

Calculation of ratio l_b/d

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

Calculation of $Mu1$ -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.4195365E-005$
 $Mu = 1.9795E+009$

with full section properties:

$b = 450.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00198039$
 $N = 20792.031$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 $we (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.53375773$
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
 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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 791.8782$

$fy1 = 659.8985$

$su1 = 0.032$

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

Shear_factor = 1.00

$lo/lo_{min} = lb/l_d = 1.00$

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

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

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

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

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 659.8985$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

$fy2 = 666.6667$

$su2 = 0.032$

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

$lo/lo_{min} = lb/l_b, min = 1.00$

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

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

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

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

with $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 666.6667$

with $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

```

shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
    2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
    v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
    c = confinement factor = 1.22442
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
    2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
    v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867
Mu = MRc (4.15) = 1.9795E+009
u = su (4.1) = 6.4195365E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

```

u = 5.2038205E-005
Mu = 1.8303E+009

```

with full section properties:

```

b = 950.00
d = 707.00
d' = 43.00
v = 0.00093808
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204

```

$$ase((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.53375773$$

$$ase1 = \text{Max}(((Aconf, \max1 - AnoConf1) / Aconf, \max1) * (Aconf, \min1 / Aconf, \max1), 0) = 0.53375773$$

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,max1 = 464100.00 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.

Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf, \max2 - AnoConf2) / Aconf, \max2) * (Aconf, \min2 / Aconf, \max2), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 2.40577$$

$$psh, x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.40577$$

$$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

$$psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

$$psh, y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305$$

$$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982

$$psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 800.00$$

$$fy1 = 666.6667$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 666.6667$$

$$\text{with } Es1 = (Es, \text{jacket} * Asl, \text{ten, jacket} + Es, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

```

y2 = 0.0025
sh2 = 0.008
ft2 = 791.8782
fy2 = 659.8985
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 659.8985
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu2-

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

$$u = 6.4195365E-005$$

$$Mu = 1.9795E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01139045$$

$$w_e (5.4c) = 0.03891204$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2560.00$$

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

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424424$$

```

c = confinement factor = 1.22442
y1 = 0.0025
sh1 = 0.008
ft1 = 791.8782
fy1 = 659.8985
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867
Mu = MRc (4.15) = 1.9795E+009
u = su (4.1) = 6.4195365E-005
-----

Calculation of ratio lb/ld
-----
Adequate Lap Length: lb/ld >= 1
-----
-----
-----

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 1.0936E+006
-----

Calculation of Shear Strength at edge 1, Vr1 = 1.0936E+006
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 1.0936E+006
knl = 1 (zero step-static loading)
-----

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

= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'jacket*Areajacket + fc'core*Areacore)/Areasection = 26.93333, but fc'0.5 <=
8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 4.00
Mu = 1122.249
Vu = 0.00043816
d = 0.8*h = 600.00
Nu = 20792.031
Ag = 337500.00
From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 916395.596
where:
Vs,jacket = Vs,j1 + Vs,j2 = 837758.041
Vs,j1 = 523598.776 is calculated for section web jacket, with:
d = 600.00
Av = 157079.633
fy = 555.5556
s = 100.00
Vs,j1 is multiplied by Colj1 = 1.00
s/d = 0.16666667
Vs,j2 = 314159.265 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.5556
s = 100.00
Vs,j2 is multiplied by Colj2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 78637.555
Vs,c1 = 78637.555 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs,c1 is multiplied by Colc1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs,c2 is multiplied by Colc2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00

```


From (11-11), ACI 440: $V_s + V_f \leq 930841.148$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 1.0936E+006$
 $knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 1122.249$
 $V_u = 0.00043816$
 $d = 0.8 * h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$
where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 930841.148$
 $bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)

Section Type: rcjctcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22442

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = 2.6259672E-008$

EDGE -B-

Shear Force, $V_b = -2.6259672E-008$

BOTH EDGES

Axial Force, $F = -20792.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1539.38$

-Compression: $A_{sc,com} = 1539.38$

-Middle: $A_{st,mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.06395$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$
with

$$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 2.4457E+009$$

$M_{u1+} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 2.4457E+009$$

$M_{u2+} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$$\phi_u = 4.6992200E-005$$

$$M_u = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.01139045$$

$$w_e (5.4c) = 0.03891204$$

$$a_{se} ((5.4d), \text{TB DY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

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

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 $Lstir1 \text{ (Length of stirrups along X)} = 2560.00$
 $Astir1 \text{ (stirrups area)} = 78.53982$
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 $Lstir2 \text{ (Length of stirrups along X)} = 1968.00$
 $Astir2 \text{ (stirrups area)} = 50.26548$

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 790.7246

fyv = 658.9372

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403

2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17674942$
 and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09092359$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09092359$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21091798$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

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

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

--->
 $\mu_u (4.8) = 0.2492127$
 $\mu_u = M_{Rc} (4.15) = 2.4457E+009$
 $u = \mu_u (4.1) = 4.6992200E-005$

Calculation of ratio l_b/d

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

Calculation of μ_{u1} -

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 4.6992200E-005$
 $\mu_u = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$
 $\alpha (5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.01139045$
 $\mu_{u1} (5.4c) = 0.03891204$
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$
 $\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
 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,max2 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.40577

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.40577
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.87305
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

```

ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
    v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942

```

and confined core properties:

```

b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
    c = confinement factor = 1.22442
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
    2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
    v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798

```

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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

```

u = 4.6992200E-005
Mu = 2.4457E+009

```

with full section properties:

```

b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

```

$$ase1 = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}})/A_{\text{conf,max1}}) * (A_{\text{conf,min1}}/A_{\text{conf,max1}}), 0) = 0.53375773$$

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.

$A_{\text{conf,max1}} = 464100.00$ 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.

$A_{\text{conf,min1}} = 395025.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max1}}$ by a length equal to half the clear spacing between external hoops.

$A_{\text{noConf1}} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}})/A_{\text{conf,max2}}) * (A_{\text{conf,min2}}/A_{\text{conf,max2}}), 0) = 0.53375773$$

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.

$A_{\text{conf,max2}} = 252164.00$ 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.

$A_{\text{conf,min2}} = 111441.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max2}}$ by a length equal to half the clear spacing between internal hoops.

$A_{\text{noConf2}} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{\text{min}} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ (5.4d)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ ((5.4d), TBDY)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{\text{sec}} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 800.00$$

$$fy1 = 666.6667$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 666.6667$$

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

$$y2 = 0.0025$$


```

sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu2-

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

$$\phi_u = 4.6992200E-005$$

$$\mu = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

$$\phi_0 (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_0) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.01139045$$

$$\phi_{ue} (5.4c) = 0.03891204$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.40577$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.40577$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.87305$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$\phi_{psh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00424424$$

$$\phi_c = \text{confinement factor} = 1.22442$$

```

y1 = 0.0025
sh1 = 0.008
ft1 = 800.00
fy1 = 666.6667
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->

```

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

--->

$$\mu_u(4.8) = 0.2492127$$

$$\mu_u = M R_c(4.15) = 2.4457E+009$$

$$u = \mu_u(4.1) = 4.6992200E-005$$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.5325E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325E+006$

$$V_{r1} = V_{c1}((10.3), ASCE 41-17) = k_n l V_{c10}$$

$$V_{c10} = 1.5325E+006$$

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

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

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

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/V_d = 2.00$$

$$\mu_u = 0.80319424$$

$$V_u = 2.6259672E-008$$

$$d = 0.8 \cdot h = 760.00$$

$$N_u = 20792.031$$

$$A_g = 427500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 1.0846E+006$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977384.381$$

$V_{s,j1} = 314159.265$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$$V_{s,j1} \text{ is multiplied by } Col_{j1} = 1.00$$

$$s/d = 0.27777778$$

$V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$$V_{s,j2} \text{ is multiplied by } Col_{j2} = 1.00$$

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$$V_{s,c1} \text{ is multiplied by } Col_{c1} = 0.00$$

$$s/d = 1.25$$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$$V_{s,c2} \text{ is multiplied by } Col_{c2} = 1.00$$

$$s/d = 0.41666667$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 1.1791E+006$$

bw = 450.00

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325E+006$

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

$V_{Col0} = 1.5325E+006$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} < = 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 0.80417674$

$V_u = 2.6259672E-008$

$d = 0.8 * h = 760.00$

$N_u = 20792.031$

$A_g = 427500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$

$V_{sj1} = 314159.265$ is calculated for section web jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{sj2} = 663225.116$ is calculated for section flange jacket, with:

$d = 760.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.13157895$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$

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

$d = 200.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.25$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$d = 600.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 0.41666667$

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

From (11-11), ACI 440: $V_s + V_f < = 1.1791E+006$

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjtcs

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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

Steel Elasticity, $E_s = 200000.00$

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d > 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 24649.088$

Shear Force, $V_2 = -5495.352$

Shear Force, $V_3 = -11.61082$

Axial Force, $F = -21204.738$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1539.38$

-Compression: $A_{sl,com} = 2475.575$

-Middle: $A_{sl,mid} = 2676.637$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

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

-Compression: $A_{sl,com,jacket} = 1859.823$

-Middle: $A_{sl,mid,jacket} = 2060.885$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,core} = 307.8761$

-Compression: $A_{sl,com,core} = 615.7522$

-Middle: $A_{sl,mid,core} = 615.7522$

Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \phi \cdot u = 0.03543103$

$u = \gamma + \rho = 0.03543103$

- Calculation of γ -

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.00338998 \text{ ((4.29), Biskinis Phd)}$

$$M_y = 8.3071E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1*L \text{ and } L_s < 2*L) = 2122.94$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.7341E+014$$

$$\text{factor} = 0.30$$

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 26.93333$$

$$N = 21204.738$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 5.7803E+014$$

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:

$$\text{flange width, } b = 950.00$$

$$\text{web width, } b_w = 450.00$$

$$\text{flange thickness, } t = 450.00$$

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

$$y_{\text{ten}} = 4.6828721E-006$$

$$\text{with } f_y = 529.9948$$

$$d = 707.00$$

$$y = 0.19959483$$

$$A = 0.01002248$$

$$B = 0.00468945$$

$$\text{with } p_t = 0.00229194$$

$$p_c = 0.00368581$$

$$p_v = 0.00398517$$

$$N = 21204.738$$

$$b = 950.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.5661781E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.19868774$$

$$A = 0.00989116$$

$$B = 0.00462988$$

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

$$\text{CONFIRMATION: } y = 0.19959483 < t/d$$

Calculation of ratio I_b/I_d

$$\text{Adequate Lap Length: } I_b/I_d \geq 1$$

- Calculation of p -

$$\text{From table 10-8: } p = 0.03204105$$

with:

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

$$\text{shear control ratio } V_y E / V_{col} O E = 1.20669$$

$$d = d_{\text{external}} = 707.00$$

$$s = s_{\text{external}} = 0.00$$

$$- t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.0035764$$

$$\text{jacket: } s_1 = A_{v1} * L_{\text{stir1}} / (s_1 * A_g) = 0.00301593$$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * L_{\text{stir2}} / (s_2 * A_g) = 0.00056047$$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1568.00$, is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

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

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

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

For the normalisation f_s of jacket is used.

$$N_{UD} = 21204.738$$

$$A_g = 562500.00$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 26.93333$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 529.9948$$

$$f_{yIE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 538.1429$$

$$p_l = Area_Tot_Long_Rein / (b \cdot d) = 0.00996292$$

$$b = 950.00$$

$$d = 707.00$$

$$f_{cE} = 26.93333$$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

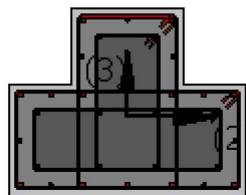
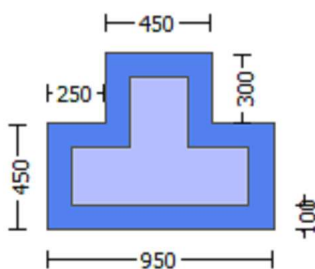
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Jacket

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, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

New material: Steel Strength, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 24649.088$

Shear Force, $V_a = -11.61082$

EDGE -B-

Bending Moment, $M_b = 10778.932$

Shear Force, $V_b = 11.61082$

BOTH EDGES

Axial Force, $F = -21204.738$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{c,com} = 2475.575$

-Middle: $As_{l,mid} = 2676.637$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = *V_n = 994409.542$

V_n ((10.3), ASCE 41-17) = $k_n * V_{CoI0} = 994409.542$

$V_{CoI} = 994409.542$

$k_n = 1.00$

displacement_ductility_demand = 0.00234563

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

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 20.80$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 3.53823$

$\mu_u = 24649.088$

$V_u = 11.61082$

$d = 0.8 \cdot h = 600.00$

$N_u = 21204.738$

$A_g = 337500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 824756.036$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 753982.237$

$V_{s,j1} = 471238.898$ is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s,j1}$ is multiplied by $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s,j2}$ is multiplied by $\text{Col},j2 = 1.00$

$s/d = 0.27777778$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 70773.799$

$V_{s,c1} = 70773.799$ is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

$V_{s,c1}$ is multiplied by $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

$V_{s,c2}$ is multiplied by $\text{Col},c2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 818016.733$

$b_w = 450.00$

displacement ductility demand is calculated as δ_u / y

- Calculation of δ_u / y for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation $\theta_r = 7.9516528E-006$

$y = (M_y \cdot L_s / 3) / \text{Eleff} = 0.00338998$ ((4.29), Biskinis Phd)

$M_y = 8.3071E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 2122.94

From table 10.5, ASCE 41_17: $\text{Eleff} = \text{factor} \cdot E_c \cdot I_g = 1.7341E+014$

factor = 0.30

$A_g = 562500.00$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 26.93333$

$N = 21204.738$

$E_c \cdot I_g = E_{c,\text{jacket}} \cdot I_{g,\text{jacket}} + E_{c,\text{core}} \cdot I_{g,\text{core}} = 5.7803E+014$

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, $b = 950.00$

web width, $b_w = 450.00$

flange thickness, $t = 450.00$

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

$y_{\text{ten}} = 4.6828721\text{E-}006$

with $f_y = 529.9948$

$d = 707.00$

$y = 0.19959483$

$A = 0.01002248$

$B = 0.00468945$

with $p_t = 0.00229194$

$p_c = 0.00368581$

$p_v = 0.00398517$

$N = 21204.738$

$b = 950.00$

$" = 0.06082037$

$y_{\text{comp}} = 1.5661781\text{E-}005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19868774$

$A = 0.00989116$

$B = 0.00462988$

with $E_s = 200000.00$

CONFIRMATION: $y = 0.19959483 < t/d$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

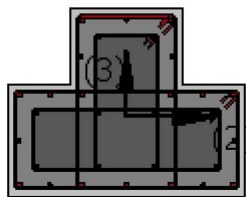
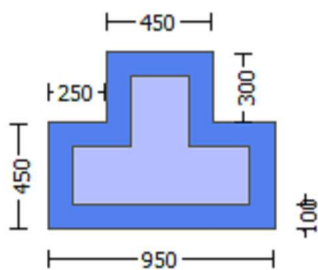
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $E_{cc} = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.22442

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -0.00043816$

EDGE -B-

Shear Force, $V_b = 0.00043816$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1539.38$
 -Compression: $As_{c,com} = 2475.575$
 -Middle: $As_{c,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.20669$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.9795E+009$
 $\mu_{u1+} = 1.8303E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.9795E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.9795E+009$
 $\mu_{u2+} = 1.8303E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.9795E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 5.2038205E-005$
 $\mu_u = 1.8303E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$
 $f_c = 33.00$
 $\alpha_1 = 0.85$ (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$

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

From (5.4b), TBDY: $\phi_u = 0.01139045$

we (5.4c) = 0.03891204

$\alpha_{se}((5.4d), \text{TBDY}) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b^2/6$ as defined at (A.2).

$\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2 (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2 ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

Shear_factor = 1.00

$lo/lo_{min} = lb/ld = 1.00$

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

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

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

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

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 791.8782$

$fy2 = 659.8985$

$su2 = 0.032$

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

$lo/lo_{min} = lb/lb_{min} = 1.00$

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

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

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

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

with $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 659.8985$

with $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

```

shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
    c = confinement factor = 1.22442
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
    2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
    v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu1-

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

```

u = 6.4195365E-005
Mu = 1.9795E+009

```

with full section properties:

```

b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204

```

$$ase((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.53375773$$

$$ase1 = \text{Max}(((Aconf, \text{max1} - AnoConf1) / Aconf, \text{max1}) * (Aconf, \text{min1} / Aconf, \text{max1}), 0) = 0.53375773$$

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,max1 = 464100.00 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.

Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf, \text{max2} - AnoConf2) / Aconf, \text{max2}) * (Aconf, \text{min2} / Aconf, \text{max2}), 0) = 0.53375773$$

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $bi^2/6$ as defined at (A.2).

$$psh, \text{min} * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 2.40577$$

$$psh, x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.40577$$

$$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00301593$$

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

$$psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00056047$$

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

$$psh, y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305$$

$$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$$

Lstir1 (Length of stirrups along X) = 2560.00

Astir1 (stirrups area) = 78.53982

$$psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$$

Lstir2 (Length of stirrups along X) = 1968.00

Astir2 (stirrups area) = 50.26548

$$Asec = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From } ((5.A5), TBDY), TBDY: cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 791.8782$$

$$fy1 = 659.8985$$

$$su1 = 0.032$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered

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

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

$$\text{with } fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 659.8985$$

$$\text{with } Es1 = (Es, \text{jacket} * Asl, \text{ten, jacket} + Es, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$


```

y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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) = 0.29493867
Mu = MRc (4.15) = 1.9795E+009
u = su (4.1) = 6.4195365E-005

```

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

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

$$u = 5.2038205E-005$$

$$Mu = 1.8303E+009$$

with full section properties:

$$b = 950.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093808$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01139045$$

$$w_e (5.4c) = 0.03891204$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2160.00$$

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1568.00$$

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2560.00$$

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

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00424424$$

```

c = confinement factor = 1.22442
y1 = 0.0025
sh1 = 0.008
ft1 = 800.00
fy1 = 666.6667
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 791.8782
fy2 = 659.8985
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 659.8985
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.04630179
2 = Asl,com/(b*d)*(fs2/fc) = 0.07370488
v = Asl,mid/(b*d)*(fsv/fc) = 0.08000444
and confined core properties:
b = 890.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05161335
2 = Asl,com/(b*d)*(fs2/fc) = 0.08216003
v = Asl,mid/(b*d)*(fsv/fc) = 0.08918226
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) = 0.13022232
Mu = MRc (4.15) = 1.8303E+009
u = su (4.1) = 5.2038205E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

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

```

u = 6.4195365E-005
Mu = 1.9795E+009

```

with full section properties:

```

b = 450.00
d = 707.00
d' = 43.00
v = 0.00198039
N = 20792.031
fc = 33.00

```

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01139045

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

From (5.4b), TBDY: cu = 0.01139045

we (5.4c) = 0.03891204

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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,max1 = 464100.00 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.

Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to bi2/6 as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to bi2/6 as defined at (A.2).

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.40577

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.40577

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047

Lstir2 (Length of stirrups along Y) = 1568.00

Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.87305
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 791.8782

fy1 = 659.8985

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.1555992$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09774821$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.16889827$
 and confined core properties:
 $b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.18749341$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.11778432$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.20351848$
 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
 --->

$su (4.8) = 0.29493867$
 $\mu_u = M_{Rc} (4.15) = 1.9795E+009$
 $u = su (4.1) = 6.4195365E-005$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 1.0936E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.0936E+006$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 1.0936E+006$
 $k_{nl} = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1122.249$
 $V_u = 0.00043816$
 $d = 0.8 * h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col_{j2} = 1.00$

$s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 930841.148$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 1.0936E+006$
 $knl = 1$ (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: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $\mu_u = 1122.249$
 $V_u = 0.00043816$
 $d = 0.8 * h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 916395.596$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 837758.041$
 $V_{sj1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{sj2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$

s = 250.00
Vs,c2 is multiplied by Col,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 930841.148
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556

Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22442
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lo_u,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 2.6259672E-008
EDGE -B-
Shear Force, Vb = -2.6259672E-008

BOTH EDGES

Axial Force, $F = -20792.031$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 6691.592$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1539.38$

-Compression: $As_{c,com} = 1539.38$

-Middle: $As_{mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.06395$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 2.4457E+009$

$Mu_{1+} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 2.4457E+009$

$Mu_{2+} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 4.6992200E-005$

$M_u = 2.4457E+009$

with full section properties:

$b = 450.00$

$d = 907.00$

$d' = 43.00$

$v = 0.0015437$

$N = 20792.031$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$

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

From (5.4b), TBDY: $\phi_u = 0.01139045$

we (5.4c) = 0.03891204

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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,max2 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.40577

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.40577
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593
Lstir1 (Length of stirrups along Y) = 2160.00
Astir1 (stirrups area) = 78.53982
psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00056047
Lstir2 (Length of stirrups along Y) = 1568.00
Astir2 (stirrups area) = 50.26548

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.87305
psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00357443
Lstir1 (Length of stirrups along X) = 2560.00
Astir1 (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00070345
Lstir2 (Length of stirrups along X) = 1968.00
Astir2 (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

$f_{tv} = 790.7246$
 $f_{yv} = 658.9372$
 $s_{uv} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
 considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv_nominal}$ and y_v , sh_v, f_{tv}, f_{yv} , it is considered
 characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $y_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 658.9372$
 with $E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.07619403$
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.07619403$
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.17674942$

and confined core properties:

$b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.09092359$
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.09092359$
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.21091798$

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

--->
 $su (4.8) = 0.2492127$
 $Mu = MR_c (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu_1 -

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

$u = 4.6992200E-005$
 $Mu = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 $w_e (5.4c) = 0.03891204$
 $ase ((5.4d), TBDY) = (ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.53375773$

$$ase1 = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}})/A_{\text{conf,max1}}) * (A_{\text{conf,min1}}/A_{\text{conf,max1}}), 0) = 0.53375773$$

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.

$A_{\text{conf,max1}} = 464100.00$ 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.

$A_{\text{conf,min1}} = 395025.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max1}}$ by a length equal to half the clear spacing between external hoops.

$A_{\text{noConf1}} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}})/A_{\text{conf,max2}}) * (A_{\text{conf,min2}}/A_{\text{conf,max2}}), 0) = 0.53375773$$

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.

$A_{\text{conf,max2}} = 252164.00$ 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.

$A_{\text{conf,min2}} = 111441.00$ is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area $A_{\text{conf,max2}}$ by a length equal to half the clear spacing between internal hoops.

$A_{\text{noConf2}} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$psh_{\text{min}} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ (5.4d)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ ((5.4d), TBDY)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{\text{sec}} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00424424$$

$$c = \text{confinement factor} = 1.22442$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 800.00$$

$$fy1 = 666.6667$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 666.6667$$

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

$$y2 = 0.0025$$

```

sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu2+

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

$$\phi_u = 4.6992200E-005$$

$$\mu = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

$$\phi_0 (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_0) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.01139045$$

$$\phi_{ue} (5.4c) = 0.03891204$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{ase2} (> \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i d_i / 6$ as defined at (A.2).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.40577$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.40577$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2160.00$$

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

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1568.00$$

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.87305$$

$$\phi_{psh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2560.00$$

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

$$\phi_{psh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00424424$$

$$\phi_c = \text{confinement factor} = 1.22442$$

```

y1 = 0.0025
sh1 = 0.008
ft1 = 800.00
fy1 = 666.6667
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->

```

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

---->

$$s_u(4.8) = 0.2492127$$

$$M_u = M_{Rc}(4.15) = 2.4457E+009$$

$$u = s_u(4.1) = 4.6992200E-005$$

Calculation of ratio I_b/I_d

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

Calculation of M_u2 -

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

$$u = 4.6992200E-005$$

$$M_u = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.01139045$$

$$\phi_{we}(5.4c) = 0.03891204$$

$$\phi_{ase}((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.53375773$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{ase2}(\geq \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{psh,min} * \phi_{fywe} = \text{Min}(\phi_{psh,x} * \phi_{fywe}, \phi_{psh,y} * \phi_{fywe}) = 2.40577$$

$$\phi_{psh,x} * \phi_{fywe} = \phi_{psh1} * \phi_{fywe1} + \phi_{psh2} * \phi_{fywe2} = 2.40577$$

$$\phi_{psh1}((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1}(\text{Length of stirrups along } Y) = 2160.00$$

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

$$\phi_{psh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2}(\text{Length of stirrups along } Y) = 1568.00$$

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

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00357443$
 $Lstir1$ (Length of stirrups along X) = 2560.00
 $Astir1$ (stirrups area) = 78.53982
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00070345$
 $Lstir2$ (Length of stirrups along X) = 1968.00
 $Astir2$ (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 790.7246

fyv = 658.9372

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403

$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07619403$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17674942$
 and confined core properties:
 $b = 390.00$
 $d = 877.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09092359$
 $2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09092359$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.21091798$
 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
 --->
 $su (4.8) = 0.2492127$
 $\mu_u = M_{Rc} (4.15) = 2.4457E+009$
 $u = su (4.1) = 4.6992200E-005$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.5325E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325E+006$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 1.5325E+006$
 $k_{nl} = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 0.80319424$
 $V_u = 2.6259672E-008$
 $d = 0.8 * h = 760.00$
 $N_u = 20792.031$
 $A_g = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$
 $V_{sj1} = 314159.265$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 663225.116$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 0.41666667$$

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

From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325E+006$

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

$$V_{Col0} = 1.5325E+006$$

$knl = 1$ (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: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 0.80417674$$

$$V_u = 2.6259672E-008$$

$$d = 0.8 * h = 760.00$$

$$N_u = 20792.031$$

$$A_g = 427500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 1.0846E+006$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 977384.381$$

$V_{s,j1} = 314159.265$ is calculated for section web jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$V_{s,j2} = 663225.116$ is calculated for section flange jacket, with:

$$d = 760.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.13157895$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.25$$

$V_{s,c2} = 107233.029$ is calculated for section flange core, with:

$$d = 600.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V_{s,c2} is multiplied by Col,c2 = 1.00
s/d = 0.41666667
V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: V_s + V_f ≤ 1.1791E+006
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjtcs

Constant Properties

Knowledge Factor, γ = 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 Primary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$
Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$
Concrete Elasticity, $E_c = 21019.039$
Steel Elasticity, $E_s = 200000.00$
Max Height, $H_{max} = 750.00$
Min Height, $H_{min} = 450.00$
Max Width, $W_{max} = 950.00$
Min Width, $W_{min} = 450.00$
Eccentricity, $E_{cc} = 250.00$
Jacket Thickness, $t_j = 100.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d > 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.6572E+007$
Shear Force, $V_2 = -5495.352$
Shear Force, $V_3 = -11.61082$
Axial Force, $F = -21204.738$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1539.38$
-Compression: $A_{sl,com} = 1539.38$
-Middle: $A_{sl,mid} = 3612.832$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,jacket} = 1231.504$
-Compression: $A_{sl,com,jacket} = 1231.504$

-Middle: $Asl_{mid,jacket} = 2689.203$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten,core} = 307.8761$
 -Compression: $Asl_{com,core} = 307.8761$
 -Middle: $Asl_{mid,core} = 923.6282$
 Mean Diameter of Tension Reinforcement, $DbL = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = \phi \cdot u = 0.03804993$
 $u = y + p = 0.03804993$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00437874$ ((4.29), Biskinis Phd))
 $M_y = 1.1430E+009$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3015.694
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6241E+014$
 $factor = 0.30$
 $A_g = 562500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$
 $N = 21204.738$
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 8.7468E+014$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 3.9309683E-006$
 with $f_y = 529.9948$
 $d = 907.00$
 $y = 0.25675026$
 $A = 0.01649296$
 $B = 0.00868413$
 with $p_t = 0.0037716$
 $p_c = 0.0037716$
 $p_v = 0.00885172$
 $N = 21204.738$
 $b = 450.00$
 $\mu = 0.04740904$
 $y_{comp} = 9.4782912E-006$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.25591414$
 $A = 0.01627686$
 $B = 0.0085861$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.03367119$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$
 shear control ratio $V_y/E/ColOE = 1.06395$
 $d = d_{external} = 907.00$
 $s = s_{external} = 0.00$

- $t = s1 + s2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00427788$

jacket: $s1 = A_{v1} \cdot L_{stir1} / (s1 \cdot A_g) = 0.00357443$
 $A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction
 $L_{stir1} = 2560.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s1 = 100.00$

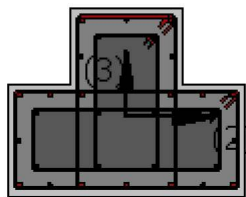
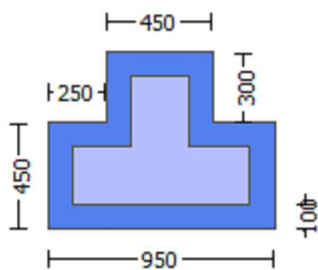
core: $s2 = A_{v2} \cdot L_{stir2} / (s2 \cdot A_g) = 0.00070345$
 $A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction
 $L_{stir2} = 1968.00$, is the total Length of all stirrups parallel to loading (shear) direction
 $s2 = 250.00$

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.
 $NUD = 21204.738$
 $A_g = 562500.00$
 $f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section_area = 26.93333$
 $f_{yE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 529.9948$
 $f_{yE} = (f_{y,ext_Trans_Reinf} \cdot s1 + f_{y,int_Trans_Reinf} \cdot s2) / (s1 + s2) = 537.2846$
 $\rho_l = Area_{Tot_Long_Rein} / (b \cdot d) = 0.01639493$
 $b = 450.00$
 $d = 907.00$
 $f_{cE} = 26.93333$

 End Of Calculation of Chord Rotation Capacity for element: column JTC1 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 JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

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

Consequently:

Jacket

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, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

New material: Steel Strength, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, $Ecc = 250.00$

Jacket Thickness, $t_j = 100.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.6572E+007$
 Shear Force, $V_a = -5495.352$
 EDGE -B-
 Bending Moment, $M_b = 82981.529$
 Shear Force, $V_b = 5495.352$
 BOTH EDGES
 Axial Force, $F = -21204.738$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{st,com} = 1539.38$
 -Middle: $A_{st,mid} = 3612.832$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = V_n = 1.3703E+006$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 1.3703E+006$
 $V_{CoI} = 1.3703E+006$
 $k_n = 1.00$
 displacement_ductility_demand = 0.02195357

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

= 1 (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 20.80$, but $f'_c^{0.5} \leq 8.3$
 MPa ((22.5.3.1, ACI 318-14))
 $M/V_d = 2.00$
 $M_u = 82981.529$
 $V_u = 5495.352$
 $d = 0.8 \cdot h = 760.00$
 $N_u = 21204.738$
 $A_g = 427500.00$
 From ((11.5.4.8), ACI 318-14): $V_s = V_{s,jacket} + V_{s,core} = 976155.669$
 where:
 $V_{s,jacket} = V_{sj1} + V_{sj2} = 879645.943$
 $V_{sj1} = 282743.339$ is calculated for section web jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj1} is multiplied by $Col_{j1} = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 596902.604$ is calculated for section flange jacket, with:
 $d = 760.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{sj2} is multiplied by $Col_{j2} = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{sc1} + V_{sc2} = 96509.726$
 $V_{sc1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$
 V_{sc1} is multiplied by $Col_{c1} = 0.00$
 $s/d = 1.25$
 $V_{sc2} = 96509.726$ is calculated for section flange core, with:
 $d = 600.00$
 $A_v = 100530.965$
 $f_y = 400.00$
 $s = 250.00$

$V_{s,c2}$ is multiplied by $Col_{c2} = 1.00$
 $s/d = 0.41666667$
 $V_f((11-3)-(11.4), ACI\ 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 1.0362E+006$
 $bw = 450.00$

displacement ductility demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 9.5628683E-006$
 $y = (M_y * L_s / 3) / E_{eff} = 0.0004356 ((4.29), Biskinis\ Phd)$
 $M_y = 1.1430E+009$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.6241E+014$
 $factor = 0.30$
 $A_g = 562500.00$
Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21204.738$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.7468E+014$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \min(\phi_{ten}, \phi_{com})$
 $\phi_{ten} = 3.9309683E-006$
with $f_y = 529.9948$
 $d = 907.00$
 $y = 0.25675026$
 $A = 0.01649296$
 $B = 0.00868413$
with $p_t = 0.0037716$
 $p_c = 0.0037716$
 $p_v = 0.00885172$
 $N = 21204.738$
 $b = 450.00$
 $\rho = 0.04740904$
 $\phi_{comp} = 9.4782912E-006$
with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.25591414$
 $A = 0.01627686$
 $B = 0.0085861$
with $E_s = 200000.00$

Calculation of ratio I_b/I_d

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

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

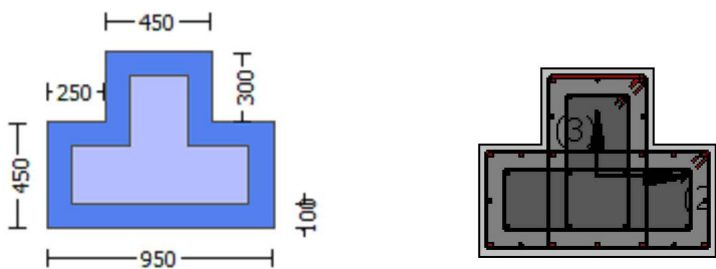
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 555.5556$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{sm} = 444.4444$

Concrete Elasticity, $E_c = 21019.039$

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height, $H_{max} = 750.00$

Min Height, $H_{min} = 450.00$

Max Width, $W_{max} = 950.00$

Min Width, $W_{min} = 450.00$

Eccentricity, Ecc = 250.00
 Jacket Thickness, tj = 100.00
 Cover Thickness, c = 25.00
 Mean Confinement Factor overall section = 1.22442
 Element Length, L = 3000.00
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,u}, \min > 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -0.00043816$
 EDGE -B-
 Shear Force, $V_b = 0.00043816$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{st,com} = 2475.575$
 -Middle: $A_{st,mid} = 2676.637$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.20669$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.3197E+006$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.9795E+009$
 $\mu_{u1+} = 1.8303E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.9795E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.9795E+009$
 $\mu_{u2+} = 1.8303E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.9795E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 5.2038205E-005$
 $\mu_u = 1.8303E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$
 $f_c = 33.00$
 ϕ_o (5A.5, TBDY) = 0.002
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \max(\phi_{cu}, \phi_{cc}) = 0.01139045$

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

From (5.4b), TBDY: $c_u = 0.01139045$

w_e (5.4c) = 0.03891204

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.40577$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.87305$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424424$

c = confinement factor = 1.22442

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 800.00$

$fy_1 = 666.6667$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

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

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

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

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} \cdot A_{s,ten,jacket} + fs_{core} \cdot A_{s,ten,core}) / A_{s,ten} = 666.6667$
 with $Es_1 = (Es_{jacket} \cdot A_{s,ten,jacket} + Es_{core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 791.8782$
 $fy_2 = 659.8985$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 659.8985$
 with $Es_2 = (Es_{jacket} \cdot A_{s,com,jacket} + Es_{core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 794.9922$
 $fy_v = 662.4935$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 662.4935$
 with $Es_v = (Es_{jacket} \cdot A_{s,mid,jacket} + Es_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.04630179$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.07370488$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / f_c) = 0.08000444$

and confined core properties:

$b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / f_c) = 0.05161335$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / f_c) = 0.08216003$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / f_c) = 0.08918226$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$ - LHS eq.(4.5) is not satisfied

--->

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

--->

$su (4.8) = 0.13022232$

$Mu = MR_c (4.15) = 1.8303E+009$

$u = su (4.1) = 5.2038205E-005$

Calculation of ratio l_b/l_d

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

Calculation of Mu1-

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

$$\mu = 6.4195365E-005$$

$$\mu_u = 1.9795E+009$$

with full section properties:

$$b = 450.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00198039$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, c_o) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01139045$$

$$\mu_{ue}(5.4c) = 0.03891204$$

$$\mu_{se}((5.4d), TBDY) = (\mu_{se1} * A_{ext} + \mu_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\mu_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{se2} (> \mu_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 2.40577$$

$$\mu_{psh,x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.40577$$

$$\mu_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$\mu_{psh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$\mu_{psh,y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.87305$$

$$\mu_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$\mu_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

```

fywe2 = 555.5556
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.00424424
c = confinement factor = 1.22442
y1 = 0.0025
sh1 = 0.008
ft1 = 791.8782
fy1 = 659.8985
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 659.8985
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 794.9922
fyv = 662.4935
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.1555992
2 = Asl,com/(b*d)*(fs2/fc) = 0.09774821
v = Asl,mid/(b*d)*(fsv/fc) = 0.16889827
and confined core properties:
b = 390.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.18749341
2 = Asl,com/(b*d)*(fs2/fc) = 0.11778432
v = Asl,mid/(b*d)*(fsv/fc) = 0.20351848
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
 --->
 μ_u (4.8) = 0.29493867
 $\mu_u = M_{Rc}$ (4.15) = 1.9795E+009
 $u = \mu_u$ (4.1) = 6.4195365E-005

Calculation of ratio I_b/I_d

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

Calculation of μ_{u2+}

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

$u = 5.2038205E-005$
 $\mu_u = 1.8303E+009$

with full section properties:

$b = 950.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00093808$
 $N = 20792.031$
 $f_c = 33.00$
 α (5A.5, TBDY) = 0.002
 Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.01139045$
 w_e (5.4c) = 0.03891204
 α_{se} ((5.4d), TBDY) = $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$
 $\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).
 $\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$
 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.
 $A_{conf,max2} = 252164.00$ 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.
 $A_{conf,min2} = 111441.00$ 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.
 $A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.40577$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.40577$
 p_{sh1} ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$
 L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982
 $psh2$ (5.4d) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$
 $psh1$ ((5.4d), TBDY) = $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
 $psh2$ ((5.4d), TBDY) = $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

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

$lo/lo_{min} = lb/ld = 1.00$

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

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

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

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

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 666.6667$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 791.8782$

$fy2 = 659.8985$

$su2 = 0.032$

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

$lo/lo_{min} = lb/lb_{min} = 1.00$

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

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

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

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

with $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 659.8985$

with $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 794.9922$

$fyv = 662.4935$

$suv = 0.032$

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

$lo/lo_{min} = lb/ld = 1.00$

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

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

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

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 662.4935$
 with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.04630179$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.07370488$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.08000444$
 and confined core properties:
 $b = 890.00$
 $d = 677.00$
 $d' = 13.00$
 fcc (5A.2, TBDY) = 40.40598
 cc (5A.5, TBDY) = 0.00424424
 c = confinement factor = 1.22442
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05161335$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.08216003$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.08918226$
 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) = 0.13022232
 $Mu = MRc$ (4.15) = 1.8303E+009
 $u = su$ (4.1) = 5.2038205E-005

 Calculation of ratio lb/ld

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

 Calculation of $Mu2$ -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 6.4195365E-005$
 $Mu = 1.9795E+009$

 with full section properties:
 $b = 450.00$
 $d = 707.00$
 $d' = 43.00$
 $v = 0.00198039$
 $N = 20792.031$
 $fc = 33.00$
 co (5A.5, TBDY) = 0.002
 Final value of cu : $cu^* = \text{shear_factor} \cdot \text{Max}(cu, cc) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01139045$
 we (5.4c) = 0.03891204
 ase ((5.4d), TBDY) = $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.53375773$
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$
 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.
 $A_{conf,max1} = 464100.00$ 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.
 $A_{conf,min1} = 395025.00$ 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.
 $A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $bi^2/6$ as defined at (A.2).

$$ase2 (>=ase1) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.40577$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.40577$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00301593$$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00056047$$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.87305$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00357443$$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00070345$$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$$A_{sec} = 562500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 791.8782$$

$$fy1 = 659.8985$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 659.8985$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 800.00$$

$$fy2 = 666.6667$$

$$su2 = 0.032$$

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

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

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

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

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

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 666.6667$
 with $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 794.9922$
 $fyv = 662.4935$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 662.4935$
 with $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.1555992$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.09774821$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.16889827$

and confined core properties:

$b = 390.00$
 $d = 677.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 40.40598$
 $cc (5A.5, TBDY) = 0.00424424$
 $c = \text{confinement factor} = 1.22442$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.18749341$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.11778432$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.20351848$

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

--->
 $su (4.8) = 0.29493867$
 $Mu = MRc (4.15) = 1.9795E+009$
 $u = su (4.1) = 6.4195365E-005$

Calculation of ratio lb/ld

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

Calculation of Shear Strength $Vr = \text{Min}(Vr1, Vr2) = 1.0936E+006$

Calculation of Shear Strength at edge 1, $Vr1 = 1.0936E+006$

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

$VCol0 = 1.0936E+006$

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

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $Mu = 1122.249$

$V_u = 0.00043816$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 916395.596$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837758.041$
 $V_{s,j1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$
 $V_{s,j2} = 314159.265$ is calculated for section flange jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j2}$ is multiplied by $Col,j2 = 1.00$
 $s/d = 0.27777778$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$
 $V_{s,c1} = 78637.555$ is calculated for section web core, with:
 $d = 440.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 1.00$
 $s/d = 0.56818182$
 $V_{s,c2} = 0.00$ is calculated for section flange core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 930841.148$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.0936E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 1.0936E+006$
 $knl = 1$ (zero step-static loading)

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

$= 1$ (normal-weight concrete)
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 4.00$
 $M_u = 1122.249$
 $V_u = 0.00043816$
 $d = 0.8 \cdot h = 600.00$
 $N_u = 20792.031$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 916395.596$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 837758.041$
 $V_{s,j1} = 523598.776$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 555.5556$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$

```

s/d = 0.16666667
Vs,j2 = 314159.265 is calculated for section flange jacket, with:
d = 360.00
Av = 157079.633
fy = 555.5556
s = 100.00
Vs,j2 is multiplied by Col,j2 = 1.00
s/d = 0.27777778
Vs,core = Vs,c1 + Vs,c2 = 78637.555
Vs,c1 = 78637.555 is calculated for section web core, with:
d = 440.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs,c1 is multiplied by Col,c1 = 1.00
s/d = 0.56818182
Vs,c2 = 0.00 is calculated for section flange core, with:
d = 200.00
Av = 100530.965
fy = 444.4444
s = 250.00
Vs,c2 is multiplied by Col,c2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 930841.148
bw = 450.00

```

```

-----
End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At local axis: 3

```

```

-----
Start Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjtcs

```

```

Constant Properties

```

```

-----
Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
#####
Max Height, Hmax = 750.00
Min Height, Hmin = 450.00
Max Width, Wmax = 950.00
Min Width, Wmin = 450.00
Eccentricity, Ecc = 250.00

```

Jacket Thickness, $t_j = 100.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.22442
 Element Length, $L = 3000.00$
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{ou}, \min > 1$)
 No FRP Wrapping

Stepwise Properties

At local axis: 2
 EDGE -A-
 Shear Force, $V_a = 2.6259672E-008$
 EDGE -B-
 Shear Force, $V_b = -2.6259672E-008$
 BOTH EDGES
 Axial Force, $F = -20792.031$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 6691.592$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1539.38$
 -Compression: $A_{sc,com} = 1539.38$
 -Middle: $A_{sc,mid} = 3612.832$

Calculation of Shear Capacity ratio, $V_e/V_r = 1.06395$
 Member Controlled by Shear ($V_e/V_r > 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 1.6305E+006$
 with
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 2.4457E+009$
 $\mu_{1+} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{1-} = 2.4457E+009$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 2.4457E+009$
 $\mu_{2+} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{2-} = 2.4457E+009$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 4.6992200E-005$
 $M_u = 2.4457E+009$

with full section properties:

$b = 450.00$
 $d = 907.00$
 $d' = 43.00$
 $v = 0.0015437$
 $N = 20792.031$
 $f_c = 33.00$
 $\phi_{co} (5A.5, TBDY) = 0.002$
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \max(\phi_u, \phi_{co}) = 0.01139045$
 The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01139045$

w_e (5.4c) = 0.03891204

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.53375773$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 2.40577$

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.40577$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} (5.4d) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.87305$

p_{sh1} ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

p_{sh2} ((5.4d), TBDY) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00424424$

c = confinement factor = 1.22442

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 800.00$

$fy_1 = 666.6667$

$su_1 = 0.032$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

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

$su_1 = 0.4 \cdot esu_1_{nominal}$ ((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 $fsy_1 = f_s/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.


```

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/lb

Adequate Lap Length: lb/lb >= 1

Calculation of Mu1-

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

$$u = 4.6992200E-005$$

$$\mu = 2.4457E+009$$

with full section properties:

$$b = 450.00$$

$$d = 907.00$$

$$d' = 43.00$$

$$v = 0.0015437$$

$$N = 20792.031$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01139045$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01139045$$

$$\phi_{ue} (5.4c) = 0.03891204$$

$$\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.53375773$$

$$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.53375773$$

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.

$A_{conf,max1} = 464100.00$ 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.

$A_{conf,min1} = 395025.00$ 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.

$A_{noConf1} = 173066.667$ is the unconfined external core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\alpha_{se2} (> \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.53375773$$

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.

$A_{conf,max2} = 252164.00$ 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.

$A_{conf,min2} = 111441.00$ 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.

$A_{noConf2} = 110709.333$ is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).

$$\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 2.40577$$

$$\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 2.40577$$

$$\phi_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00301593$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2160.00$$

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

$$\phi_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00056047$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1568.00$$

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

$$\phi_{sh,y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 2.87305$$

$$\phi_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00357443$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2560.00$$

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

$$\phi_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00070345$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1968.00$$

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

$$A_{sec} = 562500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

```

fce = 33.00
From ((5.A5), TBDY), TBDY: cc = 0.00424424
c = confinement factor = 1.22442
y1 = 0.0025
sh1 = 0.008
ft1 = 800.00
fy1 = 666.6667
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 666.6667
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 800.00
fy2 = 666.6667
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

```

u = 4.6992200E-005
Mu = 2.4457E+009

```

with full section properties:

```

b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002

```

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01139045

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

From (5.4b), TBDY: cu = 0.01139045

we (5.4c) = 0.03891204

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773

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,max1 = 464100.00 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.

Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 173066.667 is the unconfined external core area which is equal to bi2/6 as defined at (A.2).

ase2 (>=ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to bi2/6 as defined at (A.2).

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 2.40577

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.40577

psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00301593

Lstir1 (Length of stirrups along Y) = 2160.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00056047$
 L_{stir2} (Length of stirrups along Y) = 1568.00
 A_{stir2} (stirrups area) = 50.26548

psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.87305
psh1 ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00357443$
 L_{stir1} (Length of stirrups along X) = 2560.00
 A_{stir1} (stirrups area) = 78.53982
psh2 ((5.4d), TBDY) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00070345$
 L_{stir2} (Length of stirrups along X) = 1968.00
 A_{stir2} (stirrups area) = 50.26548

Asec = 562500.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00424424

c = confinement factor = 1.22442

y1 = 0.0025

sh1 = 0.008

ft1 = 800.00

fy1 = 666.6667

su1 = 0.032

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

lo/lou,min = lb/l_d = 1.00

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

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

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

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

with fs1 = (fs,jacket * Asl,tens,jacket + fs,core * Asl,tens,core) / Asl,tens = 666.6667

with Es1 = (Es,jacket * Asl,tens,jacket + Es,core * Asl,tens,core) / Asl,tens = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 800.00

fy2 = 666.6667

su2 = 0.032

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

lo/lou,min = lb/l_b,min = 1.00

su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2, ft2, fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 666.6667

with Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 790.7246

fyv = 658.9372

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv, ftv, fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

```

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942

```

and confined core properties:

```

b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798

```

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) = 0.2492127

Mu = MRc (4.15) = 2.4457E+009

u = su (4.1) = 4.6992200E-005

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 4.6992200E-005

Mu = 2.4457E+009

with full section properties:

```

b = 450.00
d = 907.00
d' = 43.00
v = 0.0015437
N = 20792.031
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01139045
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01139045
we (5.4c) = 0.03891204
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.53375773
ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.53375773
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,max1 = 464100.00 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.
Aconf,min1 = 395025.00 is the confined core area at midway between the levels of hoops and
is calculated by reducing all the dimensions of the area Aconf,max1 by a length
equal to half the clear spacing between external hoops.
AnoConf1 = 173066.667 is the unconfined external core area which is equal to bi2/6 as defined at (A.2).
ase2 (>= ase1) = Max(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.53375773

```

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 = 252164.00 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 = 111441.00 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 = 110709.333 is the unconfined internal core area which is equal to $b_i^2/6$ as defined at (A.2).
 $psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.40577$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.40577$

$psh1$ ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00301593$

L_{stir1} (Length of stirrups along Y) = 2160.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ (5.4d) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00056047$

L_{stir2} (Length of stirrups along Y) = 1568.00

A_{stir2} (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.87305$

$psh1$ ((5.4d), TBDY) = $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00357443$

L_{stir1} (Length of stirrups along X) = 2560.00

A_{stir1} (stirrups area) = 78.53982

$psh2$ ((5.4d), TBDY) = $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00070345$

L_{stir2} (Length of stirrups along X) = 1968.00

A_{stir2} (stirrups area) = 50.26548

$A_{sec} = 562500.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00424424$

c = confinement factor = 1.22442

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 800.00$

$fy1 = 666.6667$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su1 = 0.4 \cdot esu1_{nominal}$ ((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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 666.6667$

with $Es1 = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 800.00$

$fy2 = 666.6667$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

$su2 = 0.4 \cdot esu2_{nominal}$ ((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 $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 666.6667
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 790.7246
fyv = 658.9372
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 658.9372
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07619403
2 = Asl,com/(b*d)*(fs2/fc) = 0.07619403
v = Asl,mid/(b*d)*(fsv/fc) = 0.17674942
and confined core properties:
b = 390.00
d = 877.00
d' = 13.00
fcc (5A.2, TBDY) = 40.40598
cc (5A.5, TBDY) = 0.00424424
c = confinement factor = 1.22442
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09092359
2 = Asl,com/(b*d)*(fs2/fc) = 0.09092359
v = Asl,mid/(b*d)*(fsv/fc) = 0.21091798
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) = 0.2492127
Mu = MRc (4.15) = 2.4457E+009
u = su (4.1) = 4.6992200E-005

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 1.5325E+006$

Calculation of Shear Strength at edge 1, $V_{r1} = 1.5325E+006$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = knl*VColO

VColO = 1.5325E+006

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 0.80319424

Vu = 2.6259672E-008

$d = 0.8 \cdot h = 760.00$
 $Nu = 20792.031$
 $Ag = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$
 $V_{sj1} = 314159.265$ is calculated for section web jacket, with:
 $d = 360.00$
 $Av = 157079.633$
 $fy = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$
 $V_{sj2} = 663225.116$ is calculated for section flange jacket, with:
 $d = 760.00$
 $Av = 157079.633$
 $fy = 555.5556$
 $s = 100.00$
 V_{sj2} is multiplied by $Col,j2 = 1.00$
 $s/d = 0.13157895$
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 107233.029$
 $V_{s,c1} = 0.00$ is calculated for section web core, with:
 $d = 200.00$
 $Av = 100530.965$
 $fy = 444.4444$
 $s = 250.00$
 $V_{s,c1}$ is multiplied by $Col,c1 = 0.00$
 $s/d = 1.25$
 $V_{s,c2} = 107233.029$ is calculated for section flange core, with:
 $d = 600.00$
 $Av = 100530.965$
 $fy = 444.4444$
 $s = 250.00$
 $V_{s,c2}$ is multiplied by $Col,c2 = 1.00$
 $s/d = 0.41666667$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 1.1791E+006$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 1.5325E+006$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 1.5325E+006$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = Av \cdot fy \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

$= 1$ (normal-weight concrete)
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 26.93333$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 0.80417674$
 $Vu = 2.6259672E-008$
 $d = 0.8 \cdot h = 760.00$
 $Nu = 20792.031$
 $Ag = 427500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{sjacket} + V_{s,core} = 1.0846E+006$
 where:
 $V_{sjacket} = V_{sj1} + V_{sj2} = 977384.381$
 $V_{sj1} = 314159.265$ is calculated for section web jacket, with:
 $d = 360.00$
 $Av = 157079.633$
 $fy = 555.5556$
 $s = 100.00$
 V_{sj1} is multiplied by $Col,j1 = 1.00$
 $s/d = 0.27777778$

Vs,j2 = 663225.116 is calculated for section flange jacket, with:

d = 760.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.13157895

Vs,core = Vs,c1 + Vs,c2 = 107233.029

Vs,c1 = 0.00 is calculated for section web core, with:

d = 200.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c1 is multiplied by Col,c1 = 0.00

s/d = 1.25

Vs,c2 = 107233.029 is calculated for section flange core, with:

d = 600.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c2 is multiplied by Col,c2 = 1.00

s/d = 0.41666667

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 1.1791E+006

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JTC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, = 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 Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

Max Height, Hmax = 750.00

Min Height, Hmin = 450.00

Max Width, Wmax = 950.00

Min Width, Wmin = 450.00

Eccentricity, Ecc = 250.00

Jacket Thickness, tj = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 10778.932$
Shear Force, $V2 = 5495.352$
Shear Force, $V3 = 11.61082$
Axial Force, $F = -21204.738$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 6691.592$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{ten} = 1539.38$
-Compression: $As_{com} = 2475.575$
-Middle: $As_{mid} = 2676.637$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{ten,jacket} = 1231.504$
-Compression: $As_{com,jacket} = 1859.823$
-Middle: $As_{mid,jacket} = 2060.885$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{ten,core} = 307.8761$
-Compression: $As_{com,core} = 615.7522$
-Middle: $As_{mid,core} = 615.7522$
Mean Diameter of Tension Reinforcement, $Db_L = 16.57143$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = u = 0.03352348$
 $u = y + p = 0.03352348$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00148242$ ((4.29), Biskinis Phd))
 $M_y = 8.3071E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 928.352
From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.7341E+014$
 $factor = 0.30$
 $A_g = 562500.00$
Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 26.93333$
 $N = 21204.738$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 5.7803E+014$

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, $b = 950.00$
web width, $b_w = 450.00$
flange thickness, $t = 450.00$

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.6828721E-006$
with $f_y = 529.9948$
 $d = 707.00$
 $y = 0.19959483$
 $A = 0.01002248$
 $B = 0.00468945$
with $pt = 0.00229194$
 $pc = 0.00368581$
 $p_v = 0.00398517$

$N = 21204.738$
 $b = 950.00$
 $\mu = 0.06082037$
 $y_{comp} = 1.5661781E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.19868774$
 $A = 0.00989116$
 $B = 0.00462988$
 with $E_s = 200000.00$
 CONFIRMATION: $y = 0.19959483 < t/d$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.03204105$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 1.20669$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

- $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.0035764$

jacket: $s_1 = A_{v1} \cdot L_{stir1} / (s_1 \cdot A_g) = 0.00301593$

$A_{v1} = 78.53982$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2160.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot L_{stir2} / (s_2 \cdot A_g) = 0.00056047$

$A_{v2} = 50.26548$, is the area of every stirrup parallel to loading (shear) direction

$L_{stir2} = 1568.00$, is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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.

$N_{UD} = 21204.738$

$A_g = 562500.00$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section_area = 26.93333$

$f_{yE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 529.9948$

$f_{yE} = (f_{y,ext_Trans_Reinf} \cdot s_1 + f_{y,int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 538.1429$

$p_l = Area_{Tot_Long_Rein} / (b \cdot d) = 0.00996292$

$b = 950.00$

$d = 707.00$

$f_{cE} = 26.93333$

End Of Calculation of Chord Rotation Capacity for element: column JTC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

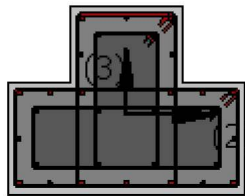
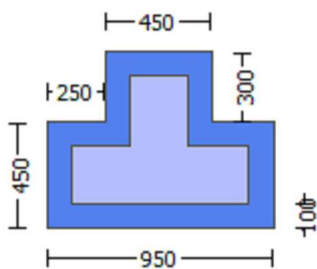
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JTC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjtcs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

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, $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 16.00$

Existing material of Primary Member: Steel Strength, $f_s = f_{s_lower_bound} = 400.00$

Concrete Elasticity, $E_c = 21019.039$

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, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

New material: Concrete Strength, $f_c = f_{cm} = 33.00$

New material: Steel Strength, $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength, $f_c = f_{cm} = 20.00$

Existing material: Steel Strength, $f_s = f_{sm} = 444.4444$

#####

Max Height, Hmax = 750.00
 Min Height, Hmin = 450.00
 Max Width, Wmax = 950.00
 Min Width, Wmin = 450.00
 Eccentricity, Ecc = 250.00
 Jacket Thickness, tj = 100.00
 Cover Thickness, c = 25.00
 Element Length, L = 3000.00
 Primary Member
 Ribbed Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_o/l_{o,u,min} = l_b/l_d \geq 1$)
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, Ma = 24649.088
 Shear Force, Va = -11.61082
 EDGE -B-
 Bending Moment, Mb = 10778.932
 Shear Force, Vb = 11.61082
 BOTH EDGES
 Axial Force, F = -21204.738
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 0.00
 -Compression: Aslc = 6691.592
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1539.38
 -Compression: Asl,com = 2475.575
 -Middle: Asl,mid = 2676.637
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.57143

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = $V_n = 1.1301E+006$
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col} = 1.1301E+006$
 $V_{Col} = 1.1301E+006$
 $knl = 1.00$
 $displacement_ductility_demand = 1.4045633E-005$

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 20.80$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 10778.932$
 $V_u = 11.61082$
 $d = 0.8 * h = 600.00$
 $N_u = 21204.738$
 $A_g = 337500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s,jacket} + V_{s,core} = 824756.036$
 where:
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 753982.237$
 $V_{s,j1} = 471238.898$ is calculated for section web jacket, with:
 $d = 600.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 $V_{s,j1}$ is multiplied by $Col,j1 = 1.00$
 $s/d = 0.16666667$

$V_{s,j2} = 282743.339$ is calculated for section flange jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

$V_{s,j2}$ is multiplied by $Col,j2 = 1.00$

$$s/d = 0.27777778$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$$

$V_{s,c1} = 70773.799$ is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

$V_{s,c1}$ is multiplied by $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$ is calculated for section flange core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

$V_{s,c2}$ is multiplied by $Col,c2 = 0.00$

$$s/d = 1.25$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From } (11-11), ACI 440: V_s + V_f \leq 818016.733$$

$$bw = 450.00$$

displacement ductility demand is calculated as δ_u / y

- Calculation of δ_u / y for END B -

for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta_r = 2.0821556E-008$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00148242 ((4.29), Biskinis Phd))$$

$$M_y = 8.3071E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 928.352$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.7341E+014$$

$$\text{factor} = 0.30$$

$$A_g = 562500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 26.93333$$

$$N = 21204.738$$

$$E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 5.7803E+014$$

Calculation of Yielding Moment M_y

Calculation of δ_u and M_y according to Annex 7 -

Assuming neutral axis within flange ($y < t/d$, compression zone rectangular) with:

$$\text{flange width, } b = 950.00$$

$$\text{web width, } bw = 450.00$$

$$\text{flange thickness, } t = 450.00$$

$$y = \text{Min}(y_{ten}, y_{com})$$

$$y_{ten} = 4.6828721E-006$$

$$\text{with } f_y = 529.9948$$

$$d = 707.00$$

$$y = 0.19959483$$

$$A = 0.01002248$$

$$B = 0.00468945$$

$$\text{with } pt = 0.00229194$$

$$pc = 0.00368581$$

$$pv = 0.00398517$$

$$N = 21204.738$$

$$b = 950.00$$

" = 0.06082037
y_comp = 1.5661781E-005
with fc = 33.00
Ec = 26999.444
y = 0.19868774
A = 0.00989116
B = 0.00462988
with Es = 200000.00
CONFIRMATION: y = 0.19959483 < t/d

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column JTC1 of floor 1
At local axis: 3
Integration Section: (b)
