

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

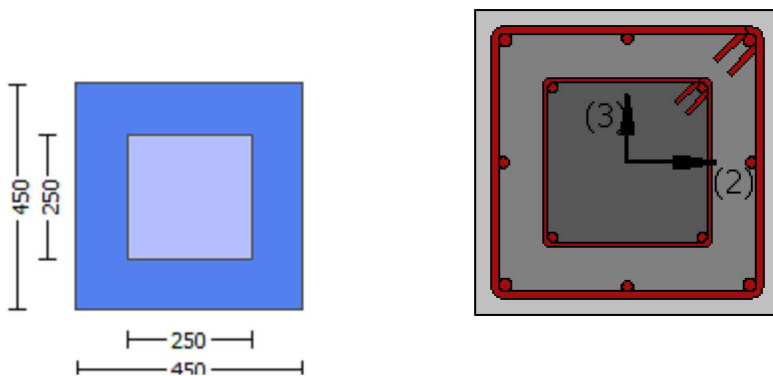
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

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Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
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Note: Especially for the calculation of  $\mu_y$  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, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
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External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping
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Stepwise Properties
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EDGE -A-
Bending Moment, Ma = -1.8336E+007
Shear Force, Va = -6110.425
EDGE -B-
Bending Moment, Mb = 0.016609
Shear Force, Vb = 6110.425
BOTH EDGES
Axial Force, F = -7504.363
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80
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New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 373730.463
Vn ((10.3), ASCE 41-17) = knl*VCol = 373730.463
VCol = 373730.463
knl = 1.00
displacement_ductility_demand = 0.04374994
-----
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).
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= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

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$M/Vd = 4.00$
 $\mu = 1.8336E+007$
 $V_u = 6110.425$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7504.363$
 $A_g = 202500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 282743.339$
 where:
 $V_{s1} = 282743.339$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 481278.84$
 $b_w = 450.00$

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 $\theta_r = 0.00019823$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00453094 ((4.29), Biskinis Phd)$
 $M_y = 1.1955E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.726
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7504.363$
 $E_c \cdot I_g = E_c \cdot I_{g_jacket} + E_c \cdot I_{g_core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of δ_u and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 4.2170414E-006$
 with ((10.1), ASCE 41-17) $f_y = \min(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.261003$
 $A = 0.01477597$
 $B = 0.00824076$
 with $p_t = 0.00620943$
 $p_c = 0.00620943$
 $p_v = 0.0021956$
 $N = 7504.363$
 $b = 450.00$
 $\alpha = 0.10565111$
 $y_{comp} = 1.9895862E-005$
 with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904673$

A = 0.01451679
B = 0.00807924
with Es = 200000.00

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

$= 1$

$d_b = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 2

column C1, Floor 1

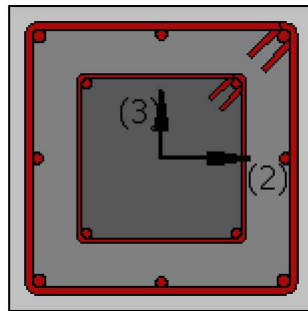
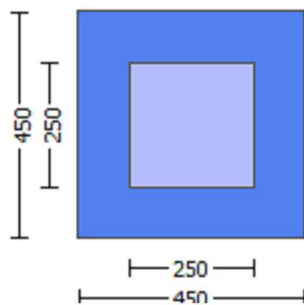
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09425

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -1.2249986E-030$

EDGE -B-

Shear Force, $V_b = 1.2249986E-030$

BOTH EDGES

Axial Force, $F = -7506.808$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 2676.637$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1137.257$
 -Compression: $As_{c,com} = 1137.257$
 -Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
 with
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.3261E+008$
 $\mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.3261E+008$
 $\mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{1+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\phi_c \text{ (5A.5, TBDY)} = 0.002$
 Final value of ϕ_{cu} : $\phi_{cu} = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_{cu} = 0.0099875$
 $\phi_{we} \text{ (5.4c)} = 0.02630475$
 $\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$
 $\phi_{ase1} = 0.2533421$
 $b_{o_1} = 390.00$
 $h_{o_1} = 390.00$
 $b_{i2_1} = 608400.00$
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$
 $b_{o_2} = 242.00$
 $h_{o_2} = 242.00$
 $b_{i2_2} = 234256.00$
 $\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.11493$

$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$
 $\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 $\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$

$$h2 = 250.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 3.11493 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00349066 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 450.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00049645 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 250.00 \end{aligned}$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \min = lb/ld = 0.14801896$$

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

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

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

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

$$\text{with } fs1 = (fs_jacket * Asl, \text{ten, jacket} + fs_core * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$$

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

$$lo/lou, \min = lb/lb, \min = 0.14801896$$

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

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

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

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

$$\text{with } fs2 = (fs_jacket * Asl, \text{com, jacket} + fs_core * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$$

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

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

$$lo/lou, \min = lb/ld = 0.14801896$$

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

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

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

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

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

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with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908

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and confined core properties:

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b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213

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Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

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Calculation of ratio lb/d

Lap Length: lb/d = 0.14801896

lb = 300.00

ld = 2026.767

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

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

= 1

db = 16.66667

Mean strength value of all re-bars: fy = 781.25

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 3.43481

Atr = Min(Atr_x,Atr_y) = 257.6106

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

s = Max(s_external,s_internal) = 250.00

n = 12.00

Calculation of Mu1-

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

u = 8.9430876E-006

Mu = 1.3261E+008

with full section properties:

b = 450.00

d = 407.00

d' = 43.00

v = 0.00136624

N = 7506.808

fc = 30.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.0099875

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

From (5.4b), TBDY: $c_u = 0.0099875$
 w_e (5.4c) = 0.02630475
 a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$
 $a_{se1} = 0.2533421$
 $b_{o_1} = 390.00$
 $h_{o_1} = 390.00$
 $b_{i2_1} = 608400.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$
 $b_{o_2} = 242.00$
 $h_{o_2} = 242.00$
 $b_{i2_2} = 234256.00$
 $p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$
 p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$
 p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.0029425$

c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

$fy_1 = 273.2614$

$su_1 = 0.0027982$

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

Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 \cdot esu_{1_nominal}$ ((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 $fsy_1 = fs_1 / 1.2$, 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 $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 273.2614$

with $Es_1 = (E_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + E_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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

Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.14801896$

$su_2 = 0.4 \cdot esu_{2_nominal}$ ((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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 273.2614$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 0.14801896$
 $suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$
 with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $fy = 781.25$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Mu2+

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0099875$$

$$\phi_{ue} \text{ (5.4c)} = 0.02630475$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 3.11493$$

$$\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{sh,y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$s_{h1} = 0.0027982$$

$$f_{t1} = 327.9137$$

$$f_{y1} = 273.2614$$

$$s_{u1} = 0.0027982$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = (fs_{jacket} * A_{s,ten,jacket} + fs_{core} * A_{s,ten,core}) / A_{s,ten} = 273.2614$
with $Es_1 = (Es_{jacket} * A_{s,ten,jacket} + Es_{core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.00087444$
 $sh_2 = 0.0027982$
 $ft_2 = 327.9137$
 $fy_2 = 273.2614$
 $su_2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = (fs_{jacket} * A_{s,com,jacket} + fs_{core} * A_{s,com,core}) / A_{s,com} = 273.2614$
with $Es_2 = (Es_{jacket} * A_{s,com,jacket} + Es_{core} * A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 $fsv = (fs_{jacket} * A_{s,mid,jacket} + fs_{mid} * A_{s,mid,core}) / A_{s,mid} = 273.2614$
with $Esv = (Es_{jacket} * A_{s,mid,jacket} + Es_{mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b * d) * (fs_1 / f_c) = 0.05655989$
 $2 = A_{s,com} / (b * d) * (fs_2 / f_c) = 0.05655989$
 $v = A_{s,mid} / (b * d) * (fsv / f_c) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{s,ten} / (b * d) * (fs_1 / f_c) = 0.07045463$
 $2 = A_{s,com} / (b * d) * (fs_2 / f_c) = 0.07045463$
 $v = A_{s,mid} / (b * d) * (fsv / f_c) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of μ_u

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

$\mu_u = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_c : $\phi_c = \text{shear_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_c = 0.0099875$

we (5.4c) = 0.02630475

ϕ_c ((5.4d), TBDY) = $(\phi_c1 \cdot A_{ext} + \phi_c2 \cdot A_{int}) / A_{sec} = 0.2533421$

$\phi_c1 = 0.2533421$

$\phi_c1_1 = 390.00$

$\phi_c1_1 = 390.00$

$\phi_c1_1 = 608400.00$

$\phi_c2 = \text{Max}(\phi_c1, \phi_c2) = 0.2533421$

$\phi_c2_1 = 242.00$

$\phi_c2_1 = 242.00$

$\phi_c2_1 = 234256.00$

$\phi_c, \text{min} \cdot F_{ywe} = \text{Min}(\phi_c, x \cdot F_{ywe}, \phi_c, y \cdot F_{ywe}) = 3.11493$

$\phi_c, x \cdot F_{ywe} = \phi_c1 \cdot F_{ywe1} + \phi_c2 \cdot F_{ywe2} = 3.11493$

ϕ_c1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h1 = 450.00$

ϕ_c2 (internal) = $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h2 = 250.00$

$\phi_c, y \cdot F_{ywe} = \phi_c1 \cdot F_{ywe1} + \phi_c2 \cdot F_{ywe2} = 3.11493$

ϕ_c1 (external) = $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = Astir_1 * ns_1 = 157.0796$
 $No\ stirups, ns_1 = 2.00$
 $h1 = 450.00$
 $ps2\ (internal) = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $No\ stirups, ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou,min = lb/ld = 0.14801896$

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

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 $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$

$ft2 = 327.9137$

$fy2 = 273.2614$

$su2 = 0.0027982$

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

$lo/lou,min = lb/lb,min = 0.14801896$

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

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

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

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

with $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 273.2614$

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

$yv = 0.00087444$
 $shv = 0.0027982$

$ftv = 327.9137$

$fyv = 273.2614$

$suv = 0.0027982$

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

$lo/lou,min = lb/ld = 0.14801896$

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

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 $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 273.2614$

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

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05655989$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.05655989$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$
 $V_{Col0} = 575966.892$
 $k_{nl} = 1$ (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: $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $Mu = 8.8568787E-012$
 $Vu = 1.2249986E-030$
 $d = 0.8 * h = 360.00$
 $Nu = 7506.808$
 $Ag = 202500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$
 where:

Vs1 = 353429.174 is calculated for jacket, with:

d = 360.00

Av = 157079.633

fy = 625.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.27777778

Vs2 = 0.00 is calculated for core, with:

d = 200.00

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 575966.892

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

VCol0 = 575966.892

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*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 8.8568787E-012

Vu = 1.2249986E-030

d = 0.8*h = 360.00

Nu = 7506.808

Ag = 202500.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174

where:

Vs1 = 353429.174 is calculated for jacket, with:

d = 360.00

Av = 157079.633

fy = 625.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.27777778

Vs2 = 0.00 is calculated for core, with:

d = 200.00

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09425

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -2.9582284E-031$

EDGE -B-

Shear Force, $V_b = 2.9582284E-031$

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 1137.257$

-Compression: $A_{sl,com} = 1137.257$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3261E+008$

$M_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

Mu1- = 1.3261E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.3261E+008
Mu2+ = 1.3261E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
Mu2- = 1.3261E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu1+

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00999875$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00999875$$

$$\phi_{we} (5.4c) = 0.02630475$$

$$\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{ase1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{psh, min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 3.11493$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

```

c = confinement factor = 1.09425
y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied

```

```

--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----

Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----

Calculation of Mu1-
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 8.9430876E-006
Mu = 1.3261E+008
-----

with full section properties:
b = 450.00
d = 407.00
d' = 43.00
v = 0.00136624
N = 7506.808
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0099875
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0099875
we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.2533421
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493
-----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645

```

Ash2 = Astir_2*ns_2 = 100.531
 No stirups, ns_2 = 2.00
 h2 = 250.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
 ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
 Ash1 = Astir_1*ns_1 = 157.0796
 No stirups, ns_1 = 2.00
 h1 = 450.00
 ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
 Ash2 = Astir_2*ns_2 = 100.531
 No stirups, ns_2 = 2.00
 h2 = 250.00

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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 = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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

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

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

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.05655989$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.05655989$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 32.82751$
 $cc \text{ (5A.5, TBDY)} = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.07045463$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.07045463$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.9)} = 0.23123015$
 $Mu = MRc \text{ (4.14)} = 1.3261E+008$
 $u = su \text{ (4.1)} = 8.9430876E-006$

 Calculation of ratio l_b/l_d

 Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

 Calculation of Mu_{2+}

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $Mu = 1.3261E+008$

 with full section properties:
 $b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co \text{ (5A.5, TBDY)} = 0.002$

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $cu = 0.0099875$
we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = $\text{Max}(ase1, ase2) = 0.2533421$
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = $\text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.11493$

psh_x*Fywe = $psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00349066$
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00049645$
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

psh_y*Fywe = $psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00349066$
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00049645$
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
c = confinement factor = 1.09425

y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982

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

lo/lou,min = $lb / ld = 0.14801896$

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 $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 273.2614$

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

y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982

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

$l_o/l_{o,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 273.2614$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.05655989$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.05655989$
 $v = A_{sl,mid} / (b * d) * (fs_v / f_c) = 0.01999908$

and confined core properties:

$b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.07045463$
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.07045463$
 $v = A_{sl,mid} / (b * d) * (fs_v / f_c) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$su (4.9) = 0.23123015$

$\mu_u = MR_c (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 30.00$, but $f'_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 12.00$

Calculation of μ_2 -

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

$\mu = 8.9430876\text{E-}006$

$\mu_u = 1.3261\text{E+}008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

μ_c (5A.5, TBDY) = 0.002

Final value of μ_c : $\mu_c^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_c) = 0.0099875$

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

From (5.4b), TBDY: $\mu_c = 0.0099875$

μ_{we} (5.4c) = 0.02630475

μ_{ase} ((5.4d), TBDY) = $(\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.2533421$

$\mu_{ase1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 3.11493$

$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.11493$

μ_{ps1} (external) = $(\mu_{Ash1} * h_1 / s_1) / A_{sec} = 0.00349066$

$\mu_{Ash1} = \mu_{Astir_1} * n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h_1 = 450.00$

μ_{ps2} (internal) = $(\mu_{Ash2} * h_2 / s_2) / A_{sec} = 0.00049645$

$\mu_{Ash2} = \mu_{Astir_2} * n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.11493$

μ_{ps1} (external) = $(\mu_{Ash1} * h_1 / s_1) / A_{sec} = 0.00349066$

$\mu_{Ash1} = \mu_{Astir_1} * n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h_1 = 450.00$

μ_{ps2} (internal) = $(\mu_{Ash2} * h_2 / s_2) / A_{sec} = 0.00049645$

$\mu_{Ash2} = \mu_{Astir_2} * n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $\mu_{cc} = 0.0029425$

μ_c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

```

fy1 = 273.2614
su1 = 0.0027982
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 0.14801896
    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 = 273.2614
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 0.14801896
    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 = 273.2614
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 0.14801896
    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 = 273.2614
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
    c = confinement factor = 1.09425
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
    v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

$= 1$

$d_b = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$V_{\text{ColO}} = 575966.892$

$k_{nl} = 1$ (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: $f'_c = (f'_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 2.0434592\text{E-}012$

$V_u = 2.9582284\text{E-}031$

$d = 0.8 \cdot h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$V_{Col0} = 575966.892$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 2.0434592E-012$

$\nu_u = 2.9582284E-031$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$bw = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, H = 250.00
 Internal Width, W = 250.00
 Cover Thickness, c = 25.00
 Element Length, L = 3000.00
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length l_b = 300.00
 No FRP Wrapping

Stepwise Properties

Bending Moment, M = 1.4066927E-009
 Shear Force, V2 = -6110.425
 Shear Force, V3 = -5.1543165E-013
 Axial Force, F = -7504.363
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: A_{st} = 0.00
 -Compression: A_{sc} = 2676.637
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten}$ = 1137.257
 -Compression: $A_{sc,com}$ = 1137.257
 -Middle: $A_{sc,mid}$ = 402.1239
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,jacket}$ = 829.3805
 -Compression: $A_{sc,com,jacket}$ = 829.3805
 -Middle: $A_{sc,mid,jacket}$ = 402.1239
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten,core}$ = 307.8761
 -Compression: $A_{sc,com,core}$ = 307.8761
 -Middle: $A_{sc,mid,core}$ = 0.00
 Mean Diameter of Tension Reinforcement, DbL = 16.80

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00226492$
 $u = y + p = 0.00226492$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00226492$ ((4.29), Biskinis Phd))
 $M_y = 1.1955E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$
 $N = 7504.363$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170414E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.261003$
 $A = 0.01477597$

```

B = 0.00824076
with pt = 0.00398711
pc = 0.00620943
pv = 0.0021956
N = 7504.363
b = 450.00
" = 0.10565111
y_comp = 1.9895862E-005
with fc = 30.00
Ec = 25742.96
y = 0.25904673
A = 0.01451679
B = 0.00807924
with Es = 200000.00

```

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{ColOE} = 0.1534981$

$d = d_{external} = 407.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 450.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 250.00$

$s_2 = 250.00$

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.

$NUD = 7504.363$

$A_g = 202500.00$

$f_{cE} = (fc_{jacket} \cdot Area_{jacket} + fc_{core} \cdot Area_{core}) / section_area = 30.00$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y_int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 625.00$

$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot Area_{ext_Trans_Reinf} + f_{y_int_Trans_Reinf} \cdot Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} =$

625.00

$\rho_l = \text{Area_Tot_Long_Rein}/(b*d) = 0.01461445$

$b = 450.00$

$d = 407.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

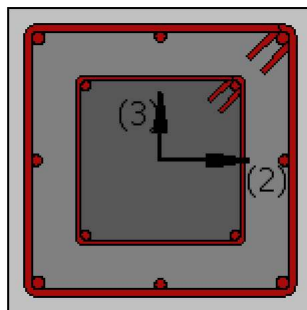
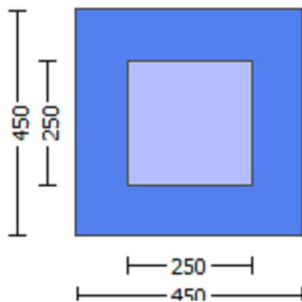
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

```

Existing Column
New material of Primary Member: Concrete Strength, fc = fc_lower_bound = 20.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of  $\gamma$  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, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
Existing Column
New material: Concrete Strength, fc = fcm = 30.00
New material: Steel Strength, fs = fsm = 625.00
#####
External Height, H = 450.00
External Width, W = 450.00
Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment, Ma = 1.4066927E-009
Shear Force, Va = -5.1543165E-013
EDGE -B-
Bending Moment, Mb = 1.3991829E-010
Shear Force, Vb = 5.1543165E-013
BOTH EDGES
Axial Force, F = -7504.363
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 1137.257
-Middle: Asl,mid = 402.1239
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80
-----
-----

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 464717.587
Vn ((10.3), ASCE 41-17) = knl*VColO = 464717.587
VCol = 464717.587
knl = 1.00
displacement_ductility_demand = 0.00
-----
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*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.4066927E-009

```


$V_u = 5.1543165E-013$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7504.363$
 $A_g = 202500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 282743.339$
 where:
 $V_{s1} = 282743.339$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 481278.84$
 $bw = 450.00$

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 $\phi = 1.4135252E-020$
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00226492 ((4.29), Biskinis Phd)$
 $M_y = 1.1955E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7504.363$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170414E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.261003$
 $A = 0.01477597$
 $B = 0.00824076$
 with $pt = 0.00620943$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7504.363$
 $b = 450.00$
 $\alpha = 0.10565111$
 $y_{comp} = 1.9895862E-005$
 with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904673$
 $A = 0.01451679$
 $B = 0.00807924$

with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

$= 1$

$d_b = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot \text{Area}_{jacket} + f_c'_{core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 4

column C1, Floor 1

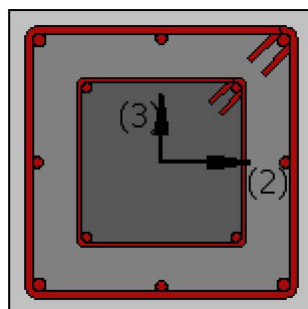
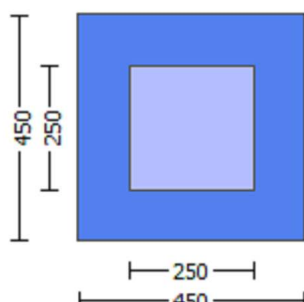
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09425

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -1.2249986E-030$

EDGE -B-

Shear Force, $V_b = 1.2249986E-030$

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Calculation of Shear Capacity ratio , $V_e/V_r = 0.1534981$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3261\text{E}+008$

$M_{u1+} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3261\text{E}+008$

$M_{u2+} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$\phi_u = 8.9430876\text{E}-006$

$M_u = 1.3261\text{E}+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_u = 0.0099875$

w_e (5.4c) = 0.02630475

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

```

s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: cc = 0.0029425
c = confinement factor = 1.09425
y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463

```

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.23123015$$

$$M_u = M_{Rc}(4.14) = 1.3261E+008$$

$$u = s_u(4.1) = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of M_{u1} -

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

$$u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \max(c_u, c_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e(5.4c) = 0.02630475$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \max(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \min(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.11493$$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$A_{sec} = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$

$f_{ywe1} = 781.25$
 $f_{ywe2} = 781.25$
 $f_{ce} = 30.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket * A_{sl, ten, jacket} + fs_core * A_{sl, ten, core}) / A_{sl, ten} = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, min = lb/lb, min = 0.14801896$

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

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 $fs2 = (fs_jacket * A_{sl, com, jacket} + fs_core * A_{sl, com, core}) / A_{sl, com} = 273.2614$

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

$yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$

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

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614
with Esv = (Esjacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----

Calculation of Mu2+
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 8.9430876E-006
Mu = 1.3261E+008
-----
with full section properties:
b = 450.00

```


$d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\phi (5A.5, TBDY) = 0.002$
 Final value of ϕ : $\phi^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_s) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_c = 0.0099875$
 $\phi_s (5.4c) = 0.02630475$
 $\phi_{se} ((5.4d), TBDY) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.2533421$
 $\phi_{se1} = 0.2533421$
 $b_{o_1} = 390.00$
 $h_{o_1} = 390.00$
 $b_{i2_1} = 608400.00$
 $\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.2533421$
 $b_{o_2} = 242.00$
 $h_{o_2} = 242.00$
 $b_{i2_2} = 234256.00$
 $\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.11493$

$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{s2} * F_{ywe2} = 3.11493$
 $\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 $\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{s2} * F_{ywe2} = 3.11493$
 $\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 $\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$A_{sec} = 202500.00$
 $s_1 = 100.00$
 $s_2 = 250.00$

$f_{ywe1} = 781.25$
 $f_{ywe2} = 781.25$
 $f_{ce} = 30.00$

From ((5.A.5), TBDY), TBDY: $\phi_c = 0.0029425$
 $\phi_c = \text{confinement factor} = 1.09425$

$y_1 = 0.00087444$
 $\phi_{sh1} = 0.0027982$
 $f_{t1} = 327.9137$
 $f_{y1} = 273.2614$
 $\phi_{su1} = 0.0027982$

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

$\phi_{lo/\phi_{ou, \min}} = \phi_b / \phi_d = 0.14801896$
 $\phi_{su1} = 0.4 * \phi_{su1_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\phi_{su1_nominal} = 0.08$,

For calculation of $\phi_{su1_nominal}$ and $y_1, \phi_{sh1}, f_{t1}, f_{y1}$, it is considered
 characteristic value $f_{sy1} = f_{s1} / 1.2$, from table 5.1, TBDY.

$y_1, \phi_{sh1}, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (\phi_b / \phi_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 273.2614$

with $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00087444$
 $\phi_{sh2} = 0.0027982$

```

ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 0.14801896
    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 = 273.2614
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
    yv = 0.00087444
    shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 0.14801896
    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 = 273.2614
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
    v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
    2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
    v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

```

```

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

```

```

su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio lb/lb

```

Lap Length: lb/lb = 0.14801896
lb = 300.00
lb = 2026.767

```

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

```

= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00

```

$s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 12.00$

Calculation of μ_2 -

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

$\mu = 8.9430876\text{E-}006$
 $\mu = 1.3261\text{E+}008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\alpha (5A.5, \text{TBDY}) = 0.002$
 Final value of μ : $\mu^* = \text{shear_factor} * \text{Max}(\mu, \alpha) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu = 0.0099875$
 $\mu (5.4c) = 0.02630475$
 $\alpha (5.4d), \text{TBDY} = (\alpha_1 * A_{\text{ext}} + \alpha_2 * A_{\text{int}}) / A_{\text{sec}} = 0.2533421$
 $\alpha_1 = 0.2533421$
 $b_{o_1} = 390.00$
 $h_{o_1} = 390.00$
 $b_{i2_1} = 608400.00$
 $\alpha_2 = \text{Max}(\alpha_1, \alpha_2) = 0.2533421$
 $b_{o_2} = 242.00$
 $h_{o_2} = 242.00$
 $b_{i2_2} = 234256.00$
 $p_{sh, \text{min}} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$

$p_{sh_x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.11493$
 $p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{\text{sec}} = 0.00349066$
 $A_{sh1} = A_{\text{stir_1}} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 $p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{\text{sec}} = 0.00049645$
 $A_{sh2} = A_{\text{stir_2}} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$p_{sh_y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.11493$
 $p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{\text{sec}} = 0.00349066$
 $A_{sh1} = A_{\text{stir_1}} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 $p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{\text{sec}} = 0.00049645$
 $A_{sh2} = A_{\text{stir_2}} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$A_{\text{sec}} = 202500.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 781.25$
 $f_{ywe2} = 781.25$

```

fce = 30.00
From ((5A.5), TBDY), TBDY: cc = 0.0029425
c = confinement factor = 1.09425
y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

```

```

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----

Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 575966.892
-----

Calculation of Shear Strength at edge 1, Vr1 = 575966.892
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 575966.892
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*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.8568787E-012
Vu = 1.2249986E-030
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174
where:
Vs1 = 353429.174 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.27777778
Vs2 = 0.00 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by Col2 = 0.00

```

s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 589443.792
bw = 450.00

Calculation of Shear Strength at edge 2, Vr2 = 575966.892
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 575966.892
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*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 8.8568787E-012
Vu = 1.2249986E-030
d = 0.8*h = 360.00
Nu = 7506.808
Ag = 202500.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174
where:
Vs1 = 353429.174 is calculated for jacket, with:
d = 360.00
Av = 157079.633
fy = 625.00
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.27777778
Vs2 = 0.00 is calculated for core, with:
d = 200.00
Av = 100530.965
fy = 625.00
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.25
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 589443.792
bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

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 = 30.00
New material of Primary Member: Steel Strength, fs = fsm = 625.00
Concrete Elasticity, Ec = 25742.96
Steel Elasticity, Es = 200000.00
Existing Column
New material of Primary Member: Concrete Strength, fc = fcm = 30.00

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
 #####
 External Height, $H = 450.00$
 External Width, $W = 450.00$
 Internal Height, $H = 250.00$
 Internal Width, $W = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.09425
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = 300.00$
 No FRP Wrapping

 Stepwise Properties

At local axis: 2
 EDGE -A-
 Shear Force, $V_a = -2.9582284E-031$
 EDGE -B-
 Shear Force, $V_b = 2.9582284E-031$
 BOTH EDGES
 Axial Force, $F = -7506.808$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 2676.637$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1137.257$
 -Compression: $As_{l,com} = 1137.257$
 -Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.1534981$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
 with
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.3261E+008$
 $Mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $Mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.3261E+008$
 $Mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the the static loading combination
 $Mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the the static loading combination

 Calculation of Mu_{1+}

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

$$\phi_u = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0099875$$

$$w_e (5.4c) = 0.02630475$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$$

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

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

For calculation of $esu_{1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $f_{sy1} = f_{s1}/1.2$, 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 $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 273.2614$
with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$
 $y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_{b,min} = 0.14801896$
 $su2 = 0.4 \cdot esu2_{nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $esu2_{nominal} = 0.08$,
For calculation of $esu2_{nominal}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $f_{sy2} = f_{s2}/1.2$, 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 $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 273.2614$
with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$
 $yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), \text{TBDY}) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and yv, shv, ftv, fyv , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, 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 $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 273.2614$
with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.05655989$
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.05655989$
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.01999908$

and confined core properties:

$b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, \text{TBDY}) = 32.82751$
 $cc (5A.5, \text{TBDY}) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07045463$
 $2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07045463$
 $v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$

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

```

= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00

```

Calculation of Mu1-

```

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 8.9430876E-006
Mu = 1.3261E+008

```

with full section properties:

```

b = 450.00
d = 407.00
d' = 43.00
v = 0.00136624
N = 7506.808
fc = 30.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.0099875
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.0099875
we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.2533421
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

Asec = 202500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A.5), TBDY), TBDY: cc = 0.0029425
c = confinement factor = 1.09425
y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425

```

$c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su(4.9) = 0.23123015$
 $Mu = MRc(4.14) = 1.3261E+008$
 $u = su(4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Mu_{2+}

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $Mu = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co(5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0099875$
 $we(5.4c) = 0.02630475$
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$
 $ase1 = 0.2533421$
 $bo_1 = 390.00$
 $ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.11493$$

$$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.11493$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00349066$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 450.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00049645$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 250.00$$

$$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.11493$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00349066$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 450.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00049645$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou,min = lb/ld = 0.14801896$$

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

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

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

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

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614$$

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

$$lo/lou,min = lb/lb,min = 0.14801896$$

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

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

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

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

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 273.2614$$

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

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v , shv , ftv , fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
Calculation of l_b,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
Mean strength value of all re-bars: $fy = 781.25$
Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = Min(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = Max(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $Mu = 1.3261E+008$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.0099875$$

$$\phi_e (5.4c) = 0.02630475$$

$$\phi_{se} ((5.4d), \text{TB DY}) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.11493$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

$$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$$

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

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

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

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

$$\text{with } fs_1 = (f_{sjacket} * A_{sl, ten, jacket} + f_{s, core} * A_{sl, ten, core}) / A_{sl, ten} = 273.2614$$

$$\text{with } Es_1 = (E_{sjacket} * A_{sl, ten, jacket} + E_{s, core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$$

```

y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio lb/ld

```

Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3

```


MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$$V_{\text{ColO}} = 575966.892$$

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

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

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

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$V_{s2} = 0.00$ is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$$s/d = 1.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 589443.792$$

$$b_w = 450.00$$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$$V_{\text{ColO}} = 575966.892$$

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

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

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

Mean concrete strength: $f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$V_u = 2.9582284E-031$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7506.808$
 $A_g = 202500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$
 where:
 $V_{s1} = 353429.174$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 589443.792$
 $bw = 450.00$

 End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
 At local axis: 2

 Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
 At local axis: 3
 Integration Section: (a)
 Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 450.00$
 External Width, $W = 450.00$
 Internal Height, $H = 250.00$
 Internal Width, $W = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.8336 \times 10^7$

Shear Force, $V_2 = -6110.425$

Shear Force, $V_3 = -5.1543165 \times 10^3$

Axial Force, $F = -7504.363$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{c,com} = 1137.257$

-Middle: $As_{mid} = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

-Compression: $As_{c,com,jacket} = 829.3805$

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{c,com,core} = 307.8761$

-Middle: $As_{mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00453094$
 $u = y + p = 0.00453094$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00453094$ ((4.29), Biskinis Phd))

$M_y = 1.1955 \times 10^8$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 3000.726

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.6391 \times 10^{13}$

factor = 0.30

$A_g = 202500.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$

$N = 7504.363$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 8.7969 \times 10^{13}$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

$y_{ten} = 4.2170414 \times 10^{-6}$

with ((10.1), ASCE 41-17) $f_y = \min(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 253.6734$

$d = 407.00$

$y = 0.261003$

$A = 0.01477597$

$B = 0.00824076$

with $pt = 0.00398711$

$pc = 0.00620943$

$pv = 0.0021956$

$N = 7504.363$

$b = 450.00$

$" = 0.10565111$

$y_{comp} = 1.9895862 \times 10^{-5}$

with $fc = 30.00$

$E_c = 25742.96$

$y = 0.25904673$

$A = 0.01451679$

$B = 0.00807924$

with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Lap Length: $l_d/l_d, \min = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{col} E = 0.1534981$

$d = d_{external} = 407.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 450.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 250.00$

$s_2 = 250.00$

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.

$N_{UD} = 7504.363$

$A_g = 202500.00$

$f'_{cE} = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / section_area = 30.00$

$f_{yIE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 625.00$

$f_{yTE} = (f_{y,ext_Trans_Reinf} \cdot Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 625.00$

$\rho_l = Area_{Tot_Long_Rein} / (b \cdot d) = 0.01461445$

$b = 450.00$

$d = 407.00$

$f'_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

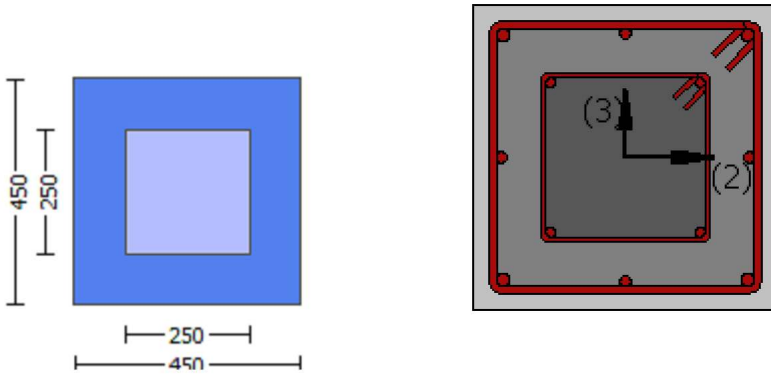
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

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

Existing Column

New material: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material: Steel Strength, $f_s = f_{sm} = 625.00$
 #####
 External Height, $H = 450.00$
 External Width, $W = 450.00$
 Internal Height, $H = 250.00$
 Internal Width, $W = 250.00$
 Cover Thickness, $c = 25.00$
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = -1.8336E+007$
 Shear Force, $V_a = -6110.425$
 EDGE -B-
 Bending Moment, $M_b = 0.016609$
 Shear Force, $V_b = 6110.425$
 BOTH EDGES
 Axial Force, $F = -7504.363$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 2676.637$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1137.257$
 -Compression: $A_{st,com} = 1137.257$
 -Middle: $A_{st,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 464717.587$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoIO} = 464717.587$
 $V_{CoI} = 464717.587$
 $k_n = 1.00$
 $displacement_ductility_demand = 0.23004534$

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: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 20.00$, but $f_c'^{0.5} \leq 8.3$
 MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 0.016609$
 $V_u = 6110.425$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7504.363$
 $A_g = 202500.00$
 From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 282743.339$
 where:
 $V_{s1} = 282743.339$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 481278.84

$$bw = 450.00$$

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 $\theta_r = 0.00010421$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00045298 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.1955E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 300.00$$

$$\text{From table 10.5, ASCE 41-17: } E_{eff} = \text{factor} * E_c * I_g = 2.6391E+013$$

$$\text{factor} = 0.30$$

$$A_g = 202500.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 30.00$$

$$N = 7504.363$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 8.7969E+013$$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 4.2170414E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 253.6734$$

$$d = 407.00$$

$$y = 0.261003$$

$$A = 0.01477597$$

$$B = 0.00824076$$

$$\text{with } p_t = 0.00620943$$

$$p_c = 0.00620943$$

$$p_v = 0.0021956$$

$$N = 7504.363$$

$$b = 450.00$$

$$\rho = 0.10565111$$

$$y_{\text{comp}} = 1.9895862E-005$$

$$\text{with } f_c = 30.00$$

$$E_c = 25742.96$$

$$y = 0.25904673$$

$$A = 0.01451679$$

$$B = 0.00807924$$

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

Calculation of ratio I_b / I_d

$$\text{Lap Length: } I_d / I_{d,\text{min}} = 0.1850237$$

$$I_b = 300.00$$

$$I_d = 1621.414$$

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

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

$$= 1$$

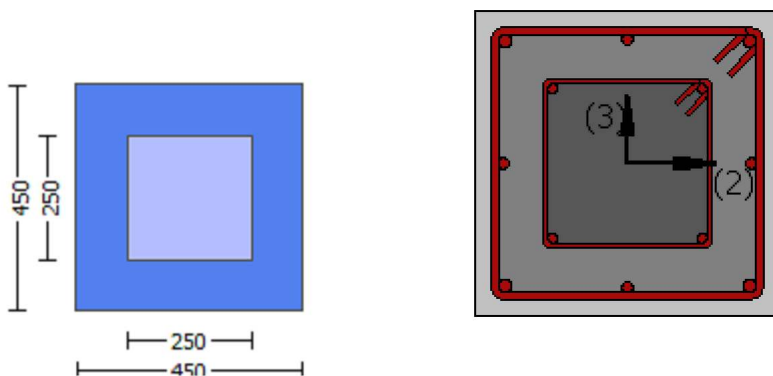
$$d_b = 16.66667$$

Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 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 JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
 New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
 Concrete Elasticity, $E_c = 25742.96$
 Steel Elasticity, $E_s = 200000.00$
 #####
 Note: Especially for the calculation of moment strengths,
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
 Jacket
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
 Existing Column
 New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
 #####
 External Height, $H = 450.00$
 External Width, $W = 450.00$
 Internal Height, $H = 250.00$
 Internal Width, $W = 250.00$
 Cover Thickness, $c = 25.00$
 Mean Confinement Factor overall section = 1.09425
 Element Length, $L = 3000.00$
 Primary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = 300.00$
 No FRP Wrapping

Stepwise Properties

At local axis: 3
 EDGE -A-
 Shear Force, $V_a = -1.2249986E-030$
 EDGE -B-
 Shear Force, $V_b = 1.2249986E-030$
 BOTH EDGES
 Axial Force, $F = -7506.808$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 2676.637$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1137.257$
 -Compression: $As_{l,com} = 1137.257$
 -Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3261E+008$
 $\mu_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
 direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3261E+008$
 $\mu_{u2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
 which is defined for the static loading combination
 $\mu_{u2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
 direction which is defined for the static loading combination

Calculation of Mu1+

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

$$u = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 273.2614$
with $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y_2 = 0.00087444$
 $sh_2 = 0.0027982$
 $ft_2 = 327.9137$
 $fy_2 = 273.2614$
 $su_2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 273.2614$
with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \min(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \max(s_external, s_internal) = 250.00$
 $n = 12.00$

Calculation of μ_1 -

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = shear_factor * \max(\mu_u, \mu_c) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.0099875$
 we (5.4c) = 0.02630475
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.2533421$
 $ase1 = 0.2533421$
 $bo_1 = 390.00$
 $ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \max(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, \min \cdot F_{ywe} = \min(psh, x \cdot F_{ywe}, psh, y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1 (external) = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 (internal) = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1 (external) = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 250.00$

 $Asec = 202500.00$

$s1 = 100.00$

$s2 = 250.00$

$fyw1 = 781.25$

$fyw2 = 781.25$

$fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$

$sh1 = 0.0027982$

$ft1 = 327.9137$

$fy1 = 273.2614$

$su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket \cdot Asl, \text{ten}, \text{jacket} + fs_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$

$sh2 = 0.0027982$

$ft2 = 327.9137$

$fy2 = 273.2614$

$su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$

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

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 $fs2 = (fs_jacket \cdot Asl, \text{com}, \text{jacket} + fs_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 273.2614$

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

$yv = 0.00087444$

$shv = 0.0027982$

$ftv = 327.9137$

$fyv = 273.2614$

$suv = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fsv = (fs_jacket \cdot Asl, \text{mid}, \text{jacket} + fs_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 273.2614$

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

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$

$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 32.82751$$

$$cc (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23123015$$

$$\mu_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of μ_{u2+}

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

$$u = 8.9430876E-006$$

$$\mu_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e (5.4c) = 0.02630475$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.11493$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$
 $su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$
 $su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$

```

with Es2 = (Esjacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
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Calculation of Mu2-
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Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0099875$$

$$\omega_e (5.4c) = 0.02630475$$

$$\alpha_{se} ((5.4d), \text{TBDY}) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$\alpha_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 3.11493$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{psh}_2 * F_{ywe2} = 3.11493$$

$$\text{ps}_1 (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\text{ps}_2 (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{psh}_2 * F_{ywe2} = 3.11493$$

$$\text{ps}_1 (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\text{ps}_2 (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_c = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$f_{t1} = 327.9137$$

$$f_{y1} = 273.2614$$

$$su_1 = 0.0027982$$

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

$$I_o / I_{ou, \min} = I_b / I_d = 0.14801896$$

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

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 $Min(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs1 = (fs_jacket \cdot Asl_ten_jacket + fs_core \cdot Asl_ten_core) / Asl_ten = 273.2614$
with $Es1 = (Es_jacket \cdot Asl_ten_jacket + Es_core \cdot Asl_ten_core) / Asl_ten = 200000.00$
 $y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 0.14801896$
 $su2 = 0.4 \cdot esu2_nominal \cdot ((5.5), TBDY) = 0.032$
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 $fs2 = (fs_jacket \cdot Asl_com_jacket + fs_core \cdot Asl_com_core) / Asl_com = 273.2614$
with $Es2 = (Es_jacket \cdot Asl_com_jacket + Es_core \cdot Asl_com_core) / Asl_com = 200000.00$
 $yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$
and also multiplied by the $shear_factor$ according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/ld = 0.14801896$
 $suv = 0.4 \cdot esuv_nominal \cdot ((5.5), TBDY) = 0.032$
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 $fsv = (fs_jacket \cdot Asl_mid_jacket + fs_mid \cdot Asl_mid_core) / Asl_mid = 273.2614$
with $Es_v = (Es_jacket \cdot Asl_mid_jacket + Es_mid \cdot Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.07045463$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.07045463$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < vs, y2$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$

Calculation of I_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 I_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \min(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = \max(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$V_{Col0} = 575966.892$

$k_{nl} = 1$ (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: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 8.8568787E-012$
 $\nu_u = 1.2249986E-030$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7506.808$
 $A_g = 202500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$
where:
 $V_{s1} = 353429.174$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 589443.792$
 $bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$V_{Col0} = 575966.892$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 8.8568787\text{E-}012$
 $V_u = 1.2249986\text{E-}030$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7506.808$
 $A_g = 202500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$
where:
 $V_{s1} = 353429.174$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $\text{Col1} = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 589443.792$
 $b_w = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$
Existing Column
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

External Height, $H = 450.00$
External Width, $W = 450.00$

Internal Height, H = 250.00
Internal Width, W = 250.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.09425
Element Length, L = 3000.00
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length l_o = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, V_a = -2.9582284E-031
EDGE -B-
Shear Force, V_b = 2.9582284E-031
BOTH EDGES
Axial Force, F = -7506.808
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t}$ = 0.00
-Compression: $A_{sl,c}$ = 2676.637
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten}$ = 1137.257
-Compression: $A_{sl,com}$ = 1137.257
-Middle: $A_{sl,mid}$ = 402.1239

Calculation of Shear Capacity ratio , V_e/V_r = 0.1534981
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3261\text{E}+008$
 $\mu_{u1+} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3261\text{E}+008$
 $\mu_{u2+} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.3261\text{E}+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.9430876\text{E}-006$
 $M_u = 1.3261\text{E}+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$

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

From (5.4b), TBDY: $c_u = 0.0099875$

w_e (5.4c) = 0.02630475

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.0029425$

c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

$fy_1 = 273.2614$

$su_1 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 \cdot esu_{1_nominal}$ ((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 $fsy_1 = fs_1 / 1.2$, 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 $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 273.2614$

with $Es_1 = (E_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + E_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.14801896$

```

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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00

```

$$n = 12.00$$

Calculation of Mu1-

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0099875$$

$$\phi_{we} \text{ (5.4c)} = 0.02630475$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{ase1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 3.11493$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (\phi_{Ash1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$\phi_{Ash1} = \phi_{Astir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (\phi_{Ash2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$\phi_{Ash2} = \phi_{Astir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (\phi_{Ash1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$\phi_{Ash1} = \phi_{Astir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (\phi_{Ash2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$\phi_{Ash2} = \phi_{Astir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$


```

su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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,min)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of μ_{2+}

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

$\mu = 8.9430876\text{E-}006$

$\mu_u = 1.3261\text{E+}008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_c : $\phi_c^* = \text{shear_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_c = 0.0099875$

ϕ_{we} (5.4c) = 0.02630475

ϕ_{ase} ((5.4d), TBDY) = $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.2533421$

$\phi_{ase1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$\phi_{sh,min} \cdot F_{ywe} = \text{Min}(\phi_{sh,x} \cdot F_{ywe}, \phi_{sh,y} \cdot F_{ywe}) = 3.11493$

$\phi_{sh,x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

ϕ_{sh1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

ϕ_{sh2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$\phi_{sh,y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $No \text{ stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $No \text{ stirups, } ns_2 = 2.00$
 $h2 = 250.00$

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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 = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05655989$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

$$cc (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.23123015$$

$$Mu = M_{Rc} (4.14) = 1.3261E+008$$

$$u = su (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/d

$$\text{Lap Length: } l_b/d = 0.14801896$$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of Mu_2 -

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

$$u = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } cu = 0.0099875$$

$$we (5.4c) = 0.02630475$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$$

```

ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

Asec = 202500.00
s1 = 100.00
s2 = 250.00
fywe1 = 781.25
fywe2 = 781.25
fce = 30.00

```

From ((5.A5), TBDY), TBDY: cc = 0.0029425
c = confinement factor = 1.09425

```

y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982

```

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

lo/lou,min = lb/d = 0.14801896

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614

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

```

y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982

```

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

lo/lou,min = lb/lb,min = 0.14801896

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 $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 273.2614$
 with $Es2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/ld = 0.14801896$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $fsv = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $Esv = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$
 $2 = A_{sl,com} / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$
 $v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (fs1 / fc) = 0.07045463$
 $2 = A_{sl,com} / (b \cdot d) \cdot (fs2 / fc) = 0.07045463$
 $v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $fy = 781.25$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $Ktr = 3.43481$
 $Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$
 where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$V_{col0} = 575966.892$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0434592E-012$

$\nu_u = 2.9582284E-031$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$V_{col0} = 575966.892$

$k_{nl} = 1$ (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: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0434592E-012$

$\nu_u = 2.9582284E-031$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

Vs2 = 0.00 is calculated for core, with:

d = 200.00

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

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 = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

External Height, H = 450.00

External Width, W = 450.00

Internal Height, H = 250.00

Internal Width, W = 250.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lb = 300.00

No FRP Wrapping

Stepwise Properties

Bending Moment, M = 1.3991829E-010

Shear Force, V2 = 6110.425

Shear Force, V3 = 5.1543165E-013

Axial Force, F = -7504.363

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 2676.637

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 1137.257

-Middle: Asl,mid = 402.1239

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,jacket} = 829.3805$

-Compression: $Asl_{com,jacket} = 829.3805$

-Middle: $Asl_{mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,core} = 307.8761$

-Compression: $Asl_{com,core} = 307.8761$

-Middle: $Asl_{mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $DbL = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00226492$

$u = y + p = 0.00226492$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00226492 ((4.29), Biskinis Phd)$

$My = 1.1955E+008$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 2.6391E+013$

$factor = 0.30$

$Ag = 202500.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$

$N = 7504.363$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 8.7969E+013$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{ten} = 4.2170414E-006$

with ((10.1), ASCE 41-17) $fy = \text{Min}(fy, 1.25 * fy * (lb/ld)^{2/3}) = 253.6734$

$d = 407.00$

$y = 0.261003$

$A = 0.01477597$

$B = 0.00824076$

with $pt = 0.00398711$

$pc = 0.00620943$

$pv = 0.0021956$

$N = 7504.363$

$b = 450.00$

$" = 0.10565111$

$y_{comp} = 1.9895862E-005$

with $fc = 30.00$

$Ec = 25742.96$

$y = 0.25904673$

$A = 0.01451679$

$B = 0.00807924$

with $Es = 200000.00$

Calculation of ratio lb/ld

Lap Length: $ld/ld_{min} = 0.1850237$

$lb = 300.00$

$ld = 1621.414$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 12.00$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{col} O E = 0.1534981$

$d = d_{\text{external}} = 407.00$

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

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 450.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 250.00$

$s_2 = 250.00$

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.

$NUD = 7504.363$

$A_g = 202500.00$

$f_{cE} = (f_{c_jacket} \cdot \text{Area}_{\text{jacket}} + f_{c_core} \cdot \text{Area}_{\text{core}}) / \text{section_area} = 30.00$

$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 625.00$

$f_{yTE} = (f_{y_ext_Trans_Reinf} \cdot \text{Area}_{\text{ext_Trans_Reinf}} + f_{y_int_Trans_Reinf} \cdot \text{Area}_{\text{int_Trans_Reinf}}) / \text{Area}_{\text{Tot_Trans_Rein}} = 625.00$

$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01461445$

$b = 450.00$

$d = 407.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

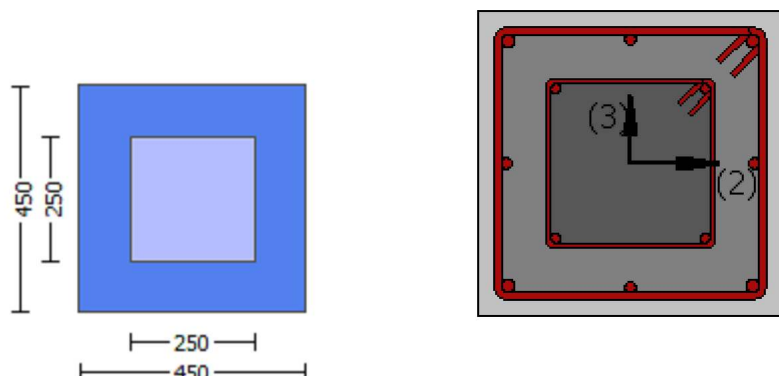
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Lap Length $l_o = l_b = 300.00$
 No FRP Wrapping

Stepwise Properties

EDGE -A-
 Bending Moment, $M_a = 1.4066927E-009$
 Shear Force, $V_a = -5.1543165E-013$
 EDGE -B-
 Bending Moment, $M_b = 1.3991829E-010$
 Shear Force, $V_b = 5.1543165E-013$
 BOTH EDGES
 Axial Force, $F = -7504.363$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 2676.637$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1137.257$
 -Compression: $A_{sl,com} = 1137.257$
 -Middle: $A_{sl,mid} = 402.1239$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 16.80$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 464717.587$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 464717.587$
 $V_{CoI} = 464717.587$
 $k_n = 1.00$
 displacement_ductility_demand = 0.00

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

= 1 (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 20.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 2.00$
 $M_u = 1.3991829E-010$
 $V_u = 5.1543165E-013$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7504.363$
 $A_g = 202500.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 282743.339$
 where:
 $V_{s1} = 282743.339$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: $V_s + V_f \leq 481278.84$
 $bw = 450.00$

displacement_ductility_demand is calculated as ϕ_y

- Calculation of ϕ_y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 6.3379047E-021$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00226492$ ((4.29), Biskinis Phd))

$M_y = 1.1955E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$

factor = 0.30

$A_g = 202500.00$

Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$

$N = 7504.363$

$E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of ϕ_y and M_y according to Annex 7 -

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

$y_{ten} = 4.2170414E-006$

with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b / l_d)^{2/3}) = 253.6734$

$d = 407.00$

$y = 0.261003$

$A = 0.01477597$

$B = 0.00824076$

with $p_t = 0.00620943$

$p_c = 0.00620943$

$p_v = 0.0021956$

$N = 7504.363$

$b = 450.00$

$\rho = 0.10565111$

$y_{comp} = 1.9895862E-005$

with $f'_c = 30.00$

$E_c = 25742.96$

$y = 0.25904673$

$A = 0.01451679$

$B = 0.00807924$

with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Lap Length: $l_d / l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

= 1

$d_b = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_{jacket} + f'_{c_core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f'_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 3.43481$

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

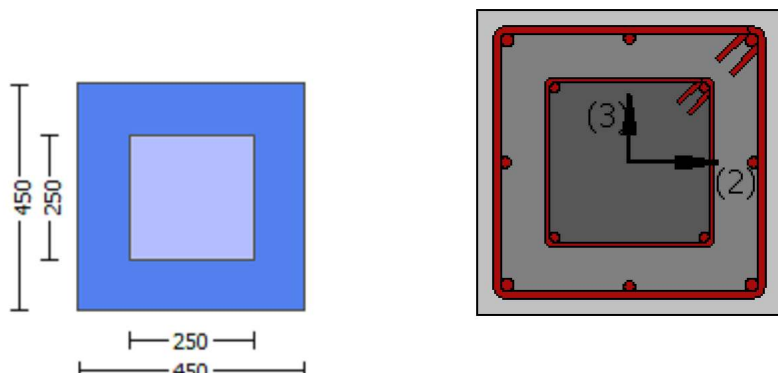
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

s = Max(s_external,s_internal) = 250.00
n = 12.00

End Of Calculation of Shear Capacity for element: column JC1 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 (u)
Edge: End
Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09425

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -1.2249986E-030$

EDGE -B-

Shear Force, $V_b = 1.2249986E-030$

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.3261E+008$

$\mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination

$\mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.3261E+008$

$\mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the static loading combination

$\mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the static loading combination

Calculation of μ_{1+}

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

$\phi_u = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.0099875$$

$$\phi_e (5.4c) = 0.02630475$$

$$\phi_{se} ((5.4d), \text{TB DY}) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.11493$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

$$l_o / l_{ou, \min} = l_b / d = 0.14801896$$

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

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

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

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

$$\text{with } fs_1 = (f_{sjacket} * A_{sl, ten, jacket} + f_{s, core} * A_{sl, ten, core}) / A_{sl, ten} = 273.2614$$

$$\text{with } Es_1 = (E_{sjacket} * A_{sl, ten, jacket} + E_{s, core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$$


```

y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio lb/ld

```

Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3

```

MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of μ_1 -

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

$$\mu = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, \phi) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.0099875$$

$$\mu (5.4c) = 0.02630475$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.11493$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.11493$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

```

fywe1 = 781.25
fywe2 = 781.25
fce = 30.00
From ((5.A5), TBDY), TBDY: cc = 0.0029425
c = confinement factor = 1.09425
y1 = 0.00087444
sh1 = 0.0027982
ft1 = 327.9137
fy1 = 273.2614
su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213

```

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

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $\mu_u (4.9) = 0.23123015$
 $M_u = M_{Rc} (4.14) = 1.3261E+008$
 $u = \mu_u (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $d_b = 16.66667$
Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $c_b = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of μ_{u2+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $M_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\phi_c (5A.5, TBDY) = 0.002$
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_{cu} = 0.0099875$
 $\phi_{we} (5.4c) = 0.02630475$
 $\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.2533421$
 $\phi_{ase1} = 0.2533421$
 $\phi_{bo_1} = 390.00$
 $\phi_{ho_1} = 390.00$
 $\phi_{bi2_1} = 608400.00$
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$
 $\phi_{bo_2} = 242.00$
 $\phi_{ho_2} = 242.00$
 $\phi_{bi2_2} = 234256.00$
 $\phi_{psh,min} \cdot F_{ywe} = \text{Min}(\phi_{psh,x} \cdot F_{ywe}, \phi_{psh,y} \cdot F_{ywe}) = 3.11493$
 $\phi_{psh_x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{ps2} \cdot F_{ywe2} = 3.11493$
 $\phi_{ps1} \text{ (external)} = (\phi_{ash1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$

$fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket * Asl, \text{ten, jacket} + fs_core * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$

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

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 $fs2 = (fs_jacket * Asl, \text{com, jacket} + fs_core * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$

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

$yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = (fs_jacket * Asl_mid_jacket + fs_mid * Asl_mid_core) / Asl_mid = 273.2614$
 with $Esv = (Es_jacket * Asl_mid_jacket + Es_mid * Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b * d) * (fs1 / fc) = 0.05655989$
 $2 = Asl_com / (b * d) * (fs2 / fc) = 0.05655989$
 $v = Asl_mid / (b * d) * (fsv / fc) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_ten / (b * d) * (fs1 / fc) = 0.07045463$
 $2 = Asl_com / (b * d) * (fs2 / fc) = 0.07045463$
 $v = Asl_mid / (b * d) * (fsv / fc) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vsy2$ - LHS eq.(4.5) is satisfied
 ---->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $fy = 781.25$
 Mean concrete strength: $fc' = (fc_jacket * Area_jacket + fc_core * Area_core) / Area_section = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $Ktr = 3.43481$
 $Atr = Min(Atr_x, Atr_y) = 257.6106$
 where Atr_x , Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = Max(s_external, s_internal) = 250.00$
 $n = 12.00$

 Calculation of $Mu2$ -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $Mu = 1.3261E+008$

 with full section properties:
 $b = 450.00$
 $d = 407.00$
 $d' = 43.00$

$v = 0.00136624$
 $N = 7506.808$
 $fc = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.0099875$
 $we (5.4c) = 0.02630475$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$
 $ase1 = 0.2533421$
 $bo_1 = 390.00$
 $ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = Max(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, min * Fy_{we} = Min(psh, x * Fy_{we}, psh, y * Fy_{we}) = 3.11493$

$psh, x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 3.11493$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh, y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 3.11493$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$A_{sec} = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fy_{we1} = 781.25$
 $fy_{we2} = 781.25$
 $f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = confinement\ factor = 1.09425$
 $y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lo_{u,min} = lb/ld = 0.14801896$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 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 $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 273.2614$
 with $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$
 $y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$

```

su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/lb
-----
Lap Length: lb/lb = 0.14801896
lb = 300.00
lb = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
lb,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00

```


$$cb = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

$$\text{Calculation of Shear Strength } V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$$

$$\text{Calculation of Shear Strength at edge 1, } V_{r1} = 575966.892$$

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

$$V_{Col0} = 575966.892$$

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

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

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

$$\text{Mean concrete strength: } f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 8.8568787\text{E-}012$$

$$V_u = 1.2249986\text{E-}030$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

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

$$s/d = 0.27777778$$

$V_{s2} = 0.00$ is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

V_{s2} is multiplied by $Col2 = 0.00$

$$s/d = 1.25$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 589443.792$$

$$b_w = 450.00$$

$$\text{Calculation of Shear Strength at edge 2, } V_{r2} = 575966.892$$

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

$$V_{Col0} = 575966.892$$

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

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

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

$$\text{Mean concrete strength: } f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 8.8568787\text{E-}012$$

$$V_u = 1.2249986\text{E-}030$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$b_w = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Mean Confinement Factor overall section = 1.09425

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -2.9582284E-031$
EDGE -B-
Shear Force, $V_b = 2.9582284E-031$
BOTH EDGES
Axial Force, $F = -7506.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{l,com} = 1137.257$
-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.1534981$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3261E+008$
 $\mu_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3261E+008$
 $\mu_{u2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $\mu_{u2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\phi_c (5A.5, \text{TBDY}) = 0.002$
Final value of ϕ_c : $\phi_c^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_c) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_c = 0.0099875$
 $\phi_w (5.4c) = 0.02630475$
 $\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$
 $\phi_{ase1} = 0.2533421$
 $\phi_{bo_1} = 390.00$
 $\phi_{ho_1} = 390.00$
 $\phi_{bi2_1} = 608400.00$
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$
 $\phi_{bo_2} = 242.00$

$ho_2 = 242.00$
 $bi_2 = 234256.00$
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 3.11493$

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00349066$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00049645$
 $Ash2 = Astir_2*ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00349066$
 $Ash1 = Astir_1*ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00049645$
 $Ash2 = Astir_2*ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 0.14801896$

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

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 $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou,min = lb/lb,min = 0.14801896$

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

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 $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 273.2614$

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

$yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$

```

fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/ld = 0.14801896
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 = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----

Calculation of Mu1-
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 8.9430876E-006

```

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.0099875$$

$$\phi (5.4c) = 0.02630475$$

$$\phi (5.4d), \text{TB DY} = (\phi_1 * A_{ext} + \phi_2 * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_1 = 0.2533421$$

$$b_{o1} = 390.00$$

$$h_{o1} = 390.00$$

$$b_{i2} = 608400.00$$

$$\phi_2 = \text{Max}(\phi_1, \phi_2) = 0.2533421$$

$$b_{o2} = 242.00$$

$$h_{o2} = 242.00$$

$$b_{i2} = 234256.00$$

$$\phi_{min} * \phi_{we} = \text{Min}(\phi_{sh}, \phi_x * \phi_{we}, \phi_y * \phi_{we}) = 3.11493$$

$$\phi_{sh} * \phi_{we} = \phi_{sh1} * \phi_{we1} + \phi_{sh2} * \phi_{we2} = 3.11493$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{sh} * \phi_{we} = \phi_{sh1} * \phi_{we1} + \phi_{sh2} * \phi_{we2} = 3.11493$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$\phi_{we1} = 781.25$$

$$\phi_{we2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with

$$\text{Shear_factor} = 1.00$$

$$l_o / l_{ou, min} = l_b / l_d = 0.14801896$$

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

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

For calculation of $esu_1_{nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $fsy_1 = fs_1 / 1.2$, from table 5.1, TB DY.

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

```

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio lb/lb

```

Lap Length: lb/lb = 0.14801896
lb = 300.00
lb = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
lb,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667

```

Mean strength value of all re-bars: $f_y = 781.25$
Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 α_1 (5A.5, TBDY) = 0.002
Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.0099875$
we (5.4c) = 0.02630475
 α_{se} ((5.4d), TBDY) = $(\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$
 $\alpha_{se1} = 0.2533421$
 $b_{o_1} = 390.00$
 $h_{o_1} = 390.00$
 $b_{i2_1} = 608400.00$
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.2533421$
 $b_{o_2} = 242.00$
 $h_{o_2} = 242.00$
 $b_{i2_2} = 234256.00$
 $p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$
 p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$
 p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$
 $A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$
No stirups, $n_{s_1} = 2.00$
 $h_1 = 450.00$
 p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$
 $A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$
No stirups, $n_{s_2} = 2.00$
 $h_2 = 250.00$

$A_{sec} = 202500.00$

$s1 = 100.00$
 $s2 = 250.00$
 $fyw1 = 781.25$
 $fyw2 = 781.25$
 $fce = 30.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 0.14801896$
 $su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 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 $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 273.2614$
 with $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$
 $y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/lb,min = 0.14801896$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 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 $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 273.2614$
 with $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$
 $yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 0.14801896$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 273.2614$
 with $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.05655989$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.05655989$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07045463$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.23123015$$

$$M_u = M_{Rc}(4.14) = 1.3261E+008$$

$$u = s_u(4.1) = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of M_{u2} -

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

$$u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \max(c_u, c_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e(5.4c) = 0.02630475$$

$$a_{se}((5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \max(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} \cdot F_{ywe} = \min(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.11493$$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$

$fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket * Asl, ten, jacket + fs_core * Asl, ten, core) / Asl, ten = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, min = lb/lb, min = 0.14801896$

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

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 $fs2 = (fs_jacket * Asl, com, jacket + fs_core * Asl, com, core) / Asl, com = 273.2614$

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

$yv = 0.00087444$
 $shv = 0.0027982$
 $ftv = 327.9137$
 $fyv = 273.2614$
 $suv = 0.0027982$

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

Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01999908$

and confined core properties:

$b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02491213$

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

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 ---->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of $l_{b,min}$ according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $fy = 781.25$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $Ktr = 3.43481$
 $Atr = Min(Atr_x, Atr_y) = 257.6106$
 where Atr_x , Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = Max(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of Shear Strength $V_r = Min(Vr1, Vr2) = 575966.892$

Calculation of Shear Strength at edge 1, $Vr1 = 575966.892$
 $Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$
 $VColO = 575966.892$
 $knl = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * fy * d / s$ ' 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: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 2.0434592E-012$
 $V_u = 2.9582284E-031$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7506.808$
 $A_g = 202500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$
where:
 $V_{s1} = 353429.174$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 589443.792$
 $b_w = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$
 $V_{Col0} = 575966.892$
 $knl = 1$ (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: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 2.0434592E-012$
 $V_u = 2.9582284E-031$
 $d = 0.8 \cdot h = 360.00$
 $N_u = 7506.808$
 $A_g = 202500.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$
where:
 $V_{s1} = 353429.174$ is calculated for jacket, with:
 $d = 360.00$
 $A_v = 157079.633$
 $f_y = 625.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.27777778$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 200.00$
 $A_v = 100530.965$
 $f_y = 625.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.25$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 589443.792$
 $b_w = 450.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$
New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$
Concrete Elasticity, $E_c = 25742.96$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 450.00$
External Width, $W = 450.00$
Internal Height, $H = 250.00$
Internal Width, $W = 250.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_b = 300.00$
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 0.016609$
Shear Force, $V_2 = 6110.425$
Shear Force, $V_3 = 5.1543165E-013$
Axial Force, $F = -7504.363$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 1137.257$
-Compression: $A_{sl,com} = 1137.257$
-Middle: $A_{sl,mid} = 402.1239$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,jacket} = 829.3805$
-Compression: $A_{sl,com,jacket} = 829.3805$
-Middle: $A_{sl,mid,jacket} = 402.1239$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten,core} = 307.8761$
-Compression: $A_{sl,com,core} = 307.8761$
-Middle: $A_{sl,mid,core} = 0.00$
Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0 \cdot u = 0.00045298$
 $u = y + p = 0.00045298$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00045298 ((4.29), \text{Biskinis Phd})$
 $M_y = 1.1955 \text{E}+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 2.6391 \text{E}+013$
 $\text{factor} = 0.30$
 $A_g = 202500.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$
 $N = 7504.363$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.7969 \text{E}+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170414 \text{E}-006$
with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b / I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.261003$
 $A = 0.01477597$
 $B = 0.00824076$
with $p_t = 0.00398711$
 $p_c = 0.00620943$
 $p_v = 0.0021956$
 $N = 7504.363$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895862 \text{E}-005$
with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904673$
 $A = 0.01451679$
 $B = 0.00807924$
with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Lap Length: $I_d / I_{d,min} = 0.1850237$
 $I_b = 300.00$
 $I_d = 1621.414$
Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
Mean strength value of all re-bars: $f_y = 625.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
where A_{tr_x}, A_{tr_y} are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$
 $n = 12.00$

- Calculation of p -

From table 10-8: $p = 0.00$

with:

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

shear control ratio $V_y E / V_{CoI} E = 0.1534981$

$d = d_{\text{external}} = 407.00$

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

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 450.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 250.00$

$s_2 = 250.00$

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.

$N_{UD} = 7504.363$

$A_g = 202500.00$

$f_{cE} = (f_{c_jacket} \cdot \text{Area_jacket} + f_{c_core} \cdot \text{Area_core}) / \text{section_area} = 30.00$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot \text{Area_ext_Long_Reinf} + f_{y_int_Long_Reinf} \cdot \text{Area_int_Long_Reinf}) / \text{Area_Tot_Long_Rein} = 625.00$

$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot \text{Area_ext_Trans_Reinf} + f_{y_int_Trans_Reinf} \cdot \text{Area_int_Trans_Reinf}) / \text{Area_Tot_Trans_Rein} = 625.00$

$\rho_l = \text{Area_Tot_Long_Rein} / (b \cdot d) = 0.01461445$

$b = 450.00$

$d = 407.00$

$f_{cE} = 30.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

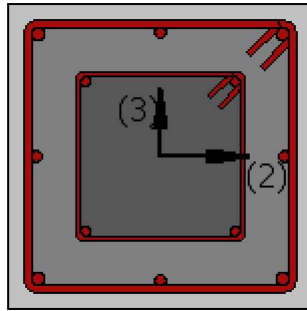
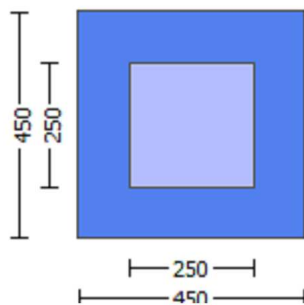
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -2.8989E+007$

Shear Force, $V_a = -9660.785$

EDGE -B-
 Bending Moment, Mb = 0.02625938
 Shear Force, Vb = 9660.785
 BOTH EDGES
 Axial Force, F = -7502.943
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 1137.257
 -Compression: Aslc = 1539.38
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1137.257
 -Compression: Asl,com = 1137.257
 -Middle: Asl,mid = 402.1239
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 373730.322
 Vn ((10.3), ASCE 41-17) = knl*VColO = 373730.322
 VCol = 373730.322
 knl = 1.00
 displacement_ductility_demand = 0.06917026

 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*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 4.00
 Mu = 2.8989E+007
 Vu = 9660.785
 d = 0.8*h = 360.00
 Nu = 7502.943
 Ag = 202500.00
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 282743.339
 where:
 Vs1 = 282743.339 is calculated for jacket, with:
 d = 360.00
 Av = 157079.633
 fy = 500.00
 s = 100.00
 Vs1 is multiplied by Col1 = 1.00
 s/d = 0.27777778
 Vs2 = 0.00 is calculated for core, with:
 d = 200.00
 Av = 100530.965
 fy = 500.00
 s = 250.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.25
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 481278.84
 bw = 450.00

 displacement_ductility_demand is calculated as / y

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

 From analysis, chord rotation = 0.00031341
 y = (My*Ls/3)/Eleff = 0.00453093 ((4.29),Biskinis Phd))
 My = 1.1954E+008
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 3000.726
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.6391E+013

factor = 0.30
 Ag = 202500.00
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 N = 7502.943
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00620943$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $fc = 30.00$
 $Ec = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $Es = 200000.00$

Calculation of ratio l_b/d

Lap Length: $l_d/l_{d,min} = 0.1850237$
 $l_b = 300.00$
 $l_d = 1621.414$
 Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $l_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 625.00$
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

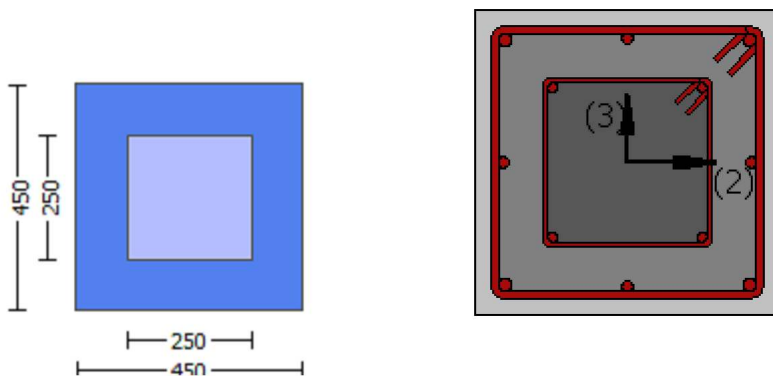
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.09425
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -1.2249986E-030$
EDGE -B-
Shear Force, $V_b = 1.2249986E-030$
BOTH EDGES
Axial Force, $F = -7506.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{c,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3261E+008$
 $\mu_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3261E+008$
 $\mu_{u2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\alpha = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.0099875$

```

we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.2533421
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

Asec = 202500.00

```

```

s1 = 100.00

```

```

s2 = 250.00

```

```

fywe1 = 781.25

```

```

fywe2 = 781.25

```

```

fce = 30.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.0029425

```

```

c = confinement factor = 1.09425

```

```

y1 = 0.00087444

```

```

sh1 = 0.0027982

```

```

ft1 = 327.9137

```

```

fy1 = 273.2614

```

```

su1 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb = 0.14801896

```

```

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 = 273.2614

```

```

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

```

```

y2 = 0.00087444

```

```

sh2 = 0.0027982

```

```

ft2 = 327.9137

```

```

fy2 = 273.2614

```

```

su2 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb,min = 0.14801896

```

```

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

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 273.2614$

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

$y_v = 0.00087444$

$sh_v = 0.0027982$

$ft_v = 327.9137$

$fy_v = 273.2614$

$suv = 0.0027982$

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

$lo/lo_{u,min} = lb/ld = 0.14801896$

$suv = 0.4 \cdot es_{u_nominal} ((5.5), TBDY) = 0.032$

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

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.05655989$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.05655989$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

$cc (5A.5, TBDY) = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.07045463$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.07045463$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

$Mu = MRc (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.14801896$

$lb = 300.00$

$ld = 2026.767$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of Mu1-

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

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
 For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 273.2614$
 with $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y_2 = 0.00087444$
 $sh_2 = 0.0027982$
 $ft_2 = 327.9137$
 $fy_2 = 273.2614$
 $su_2 = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 273.2614$
 with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

 Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot Area_jacket + f'_{c_core} \cdot Area_core) / Area_section = 30.00$, but $f'_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_external, s_internal) = 250.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.0099875$
 we (5.4c) = 0.02630475
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.2533421$
 $ase1 = 0.2533421$
 $bo_1 = 390.00$
 $ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2$ (internal) = $(Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 250.00$

 $Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fyw1 = 781.25$
 $fyw2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$

$ft1 = 327.9137$
 $fy1 = 273.2614$

$su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket \cdot Asl, \text{ten}, \text{jacket} + fs_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$

$sh2 = 0.0027982$

$ft2 = 327.9137$

$fy2 = 273.2614$

$su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$

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

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 $fs2 = (fs_jacket \cdot Asl, \text{com}, \text{jacket} + fs_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 273.2614$

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

$yv = 0.00087444$

$shv = 0.0027982$

$ftv = 327.9137$

$fyv = 273.2614$

$suv = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fsv = (fs_jacket \cdot Asl, \text{mid}, \text{jacket} + fs_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 273.2614$

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

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$

$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 32.82751$$

$$cc (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f'_c = (f'_c_{\text{jacket}} * \text{Area}_{\text{jacket}} + f'_c_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of M_{u2} -

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

$$u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e (5.4c) = 0.02630475$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.11493$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$
 $su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$
 $su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$

```

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----
-----
-----
-----

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Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$V_{Col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$V_{Col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

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 = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 781.25

Existing Column

New material: Steel Strength, fs = 1.25*fsm = 781.25

#####

External Height, H = 450.00

External Width, W = 450.00

Internal Height, H = 250.00

Internal Width, W = 250.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.09425

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lo = 300.00

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = -2.9582284E-031

EDGE -B-

Shear Force, Vb = 2.9582284E-031

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_{lt} = 0.00$

-Compression: $As_{lc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3261E+008$

$Mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3261E+008$

$Mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.9430876E-006$

$M_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_u = 0.0099875$

we (5.4c) $= 0.02630475$

$ase ((5.4d), \text{TBDY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$

$ase1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi2_1 = 608400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi2_2 = 234256.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$

$ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h1 = 450.00$

$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00049645$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, ns_2 = 2.00
h2 = 250.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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 = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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

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

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

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

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 32.82751$
 $cc \text{ (5A.5, TBDY)} = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.9)} = 0.23123015$
 $\mu_u = M_{Rc} \text{ (4.14)} = 1.3261E+008$
 $u = su \text{ (4.1)} = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

 Calculation of μ_{u1} -

 Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

 with full section properties:
 $b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co \text{ (5A.5, TBDY)} = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.0099875$

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

From (5.4b), TBDY: $c_u = 0.0099875$

w_e (5.4c) = 0.02630475

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.0029425$

c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

$fy_1 = 273.2614$

$su_1 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 \cdot esu_{1_nominal}$ ((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 $fsy_1 = fs_1 / 1.2$, 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 $fs_1 = (f_{s, jacket} \cdot A_{s, ten, jacket} + f_{s, core} \cdot A_{s, ten, core}) / A_{s, ten} = 273.2614$

with $Es_1 = (E_{s, jacket} \cdot A_{s, ten, jacket} + E_{s, core} \cdot A_{s, ten, core}) / A_{s, ten} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.14801896$

```

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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00

```

$$n = 12.00$$

Calculation of Mu2+

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0099875$$

$$\phi_{we} \text{ (5.4c)} = 0.02630475$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{ase1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.11493$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

```

su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of μ_u

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

$\mu_u = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_u (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_u = 0.0099875$

ϕ_u (5.4c) = 0.02630475

ϕ_{u1} ((5.4d), TBDY) = $(\phi_{u1} \cdot A_{ext} + \phi_{u2} \cdot A_{int}) / A_{sec} = 0.2533421$

$\phi_{u1} = 0.2533421$

$b_{o1} = 390.00$

$h_{o1} = 390.00$

$b_{i2} = 608400.00$

$\phi_{u2} = \text{Max}(\phi_{u1}, \phi_{u2}) = 0.2533421$

$b_{o2} = 242.00$

$h_{o2} = 242.00$

$b_{i2} = 234256.00$

$\phi_{sh,min} \cdot F_{ywe} = \text{Min}(\phi_{sh,x} \cdot F_{ywe}, \phi_{sh,y} \cdot F_{ywe}) = 3.11493$

$\phi_{sh,x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

ϕ_{sh1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

ϕ_{sh2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$\phi_{sh,y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 450.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

$$\text{From } ((5A5), \text{ TBDY}), \text{ TBDY: } cc = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \min = lb/ld = 0.14801896$$

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

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

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

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

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$$

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

$$lo/lou, \min = lb/lb, \min = 0.14801896$$

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

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

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

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

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 273.2614$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

$$lo/lou, \min = lb/ld = 0.14801896$$

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

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

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

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

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 273.2614$$

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.05655989$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05655989$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

$$c_c (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/d

$$\text{Lap Length: } l_b/d = 0.14801896$$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

$$\text{Calculation of Shear Strength } V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$$

$$\text{Calculation of Shear Strength at edge 1, } V_{r1} = 575966.892$$

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

$$V_{Col0} = 575966.892$$

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

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).

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

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 \cdot h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, Vr2 = 575966.892

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

$$VCol0 = 575966.892$$

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$\mu_v = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 2.2188820E-009$

Shear Force, $V_2 = -9660.785$

Shear Force, $V_3 = -8.1491463E-013$

Axial Force, $F = -7502.943$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1137.257$

-Compression: $As_c = 1539.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

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

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{l,com,core} = 307.8761$

-Middle: $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03820662$

$u = y + p = 0.03820662$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00226492$ ((4.29), Biskinis Phd))

$M_y = 1.1954E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41-17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7502.943$
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00398711$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $\rho = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Lap Length: $I_d/I_{d,min} = 0.1850237$
 $I_b = 300.00$
 $I_d = 1621.414$
 Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 625.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

- Calculation of ρ_p -

From table 10-8: $\rho_p = 0.0359417$
 with:
 - Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$
 shear control ratio $V_y E / V_{col} E = 0.1534981$
 $d = d_{external} = 407.00$

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

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 450.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 250.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c_jacket} \cdot A_{\text{jacket}} + f_{c_core} \cdot A_{\text{core}}) / \text{section_area} = 30.00$$

$$f_{yE} = (f_{y_ext_Long_Reinf} \cdot A_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot A_{\text{int_Long_Reinf}}) / A_{\text{Tot_Long_Rein}} = 625.00$$

$$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot A_{\text{ext_Trans_Reinf}} + f_{y_int_Trans_Reinf} \cdot A_{\text{int_Trans_Reinf}}) / A_{\text{Tot_Trans_Rein}} = 625.00$$

$$\rho_l = A_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

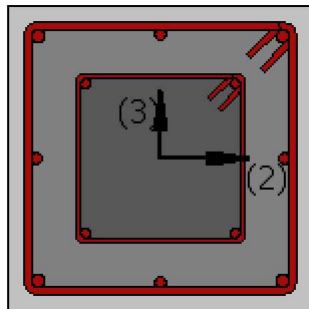
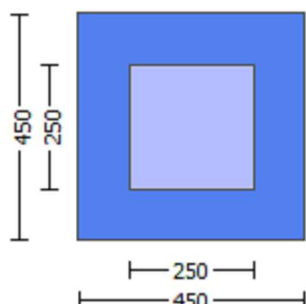
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 2.2188820E-009$

Shear Force, $V_a = -8.1491463E-013$

EDGE -B-
 Bending Moment, Mb = 2.2636163E-010
 Shear Force, Vb = 8.1491463E-013
 BOTH EDGES
 Axial Force, F = -7502.943
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 1137.257
 -Compression: Aslc = 1539.38
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1137.257
 -Compression: Asl,com = 1137.257
 -Middle: Asl,mid = 402.1239
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 464717.306
 Vn ((10.3), ASCE 41-17) = knl*VCol0 = 464717.306
 VCol = 464717.306
 knl = 1.00
 displacement_ductility_demand = 0.00

 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*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
 Mu = 2.2188820E-009
 Vu = 8.1491463E-013
 d = 0.8*h = 360.00
 Nu = 7502.943
 Ag = 202500.00
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 282743.339
 where:
 Vs1 = 282743.339 is calculated for jacket, with:
 d = 360.00
 Av = 157079.633
 fy = 500.00
 s = 100.00
 Vs1 is multiplied by Col1 = 1.00
 s/d = 0.27777778
 Vs2 = 0.00 is calculated for core, with:
 d = 200.00
 Av = 100530.965
 fy = 500.00
 s = 250.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.25
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 481278.84
 bw = 450.00

 displacement_ductility_demand is calculated as / y

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

 From analysis, chord rotation = 2.2348305E-020
 y = (My*Ls/3)/Eleff = 0.00226492 ((4.29),Biskinis Phd))
 My = 1.1954E+008
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.6391E+013

factor = 0.30
 Ag = 202500.00
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 N = 7502.943
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00620943$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $fc = 30.00$
 $Ec = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $Es = 200000.00$

Calculation of ratio l_b/d

Lap Length: $l_d/l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

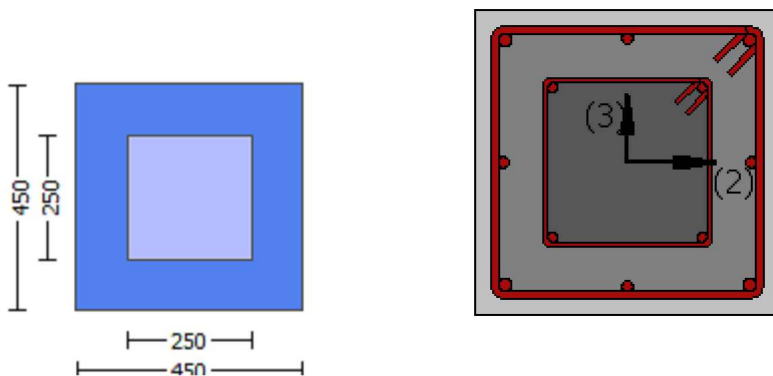
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.09425
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -1.2249986E-030$
EDGE -B-
Shear Force, $V_b = 1.2249986E-030$
BOTH EDGES
Axial Force, $F = -7506.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{l,com} = 1137.257$
-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3261E+008$
 $\mu_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3261E+008$
 $\mu_{u2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\alpha = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.0099875$

```

we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.2533421
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

Asec = 202500.00

```

```

s1 = 100.00

```

```

s2 = 250.00

```

```

fywe1 = 781.25

```

```

fywe2 = 781.25

```

```

fce = 30.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.0029425

```

```

c = confinement factor = 1.09425

```

```

y1 = 0.00087444

```

```

sh1 = 0.0027982

```

```

ft1 = 327.9137

```

```

fy1 = 273.2614

```

```

su1 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb = 0.14801896

```

```

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 = 273.2614

```

```

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

```

```

y2 = 0.00087444

```

```

sh2 = 0.0027982

```

```

ft2 = 327.9137

```

```

fy2 = 273.2614

```

```

su2 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb,min = 0.14801896

```

```

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 $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 273.2614$

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

$y_v = 0.00087444$

$sh_v = 0.0027982$

$ft_v = 327.9137$

$fy_v = 273.2614$

$s_{uv} = 0.0027982$

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

$l_o/l_{ou,min} = l_b/l_d = 0.14801896$

$s_{uv} = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

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

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

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

with $fs_v = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.05655989$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05655989$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

$cc (5A.5, TBDY) = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.07045463$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.07045463$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

$\mu_u = MR_c (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of Mu1-

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0099875$$

$$\phi_{ue} \text{ (5.4c)} = 0.02630475$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 3.11493$$

$$\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{sh,y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 273.2614$
with $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y_2 = 0.00087444$
 $sh_2 = 0.0027982$
 $ft_2 = 327.9137$
 $fy_2 = 273.2614$
 $su_2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 273.2614$
with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 co (5A.5, TBDY) = 0.002
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.0099875$
 we (5.4c) = 0.02630475
 ase ((5.4d), TBDY) = $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.2533421$
 $ase1 = 0.2533421$
 $bo_1 = 390.00$
 $ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2$ (internal) = $(Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
No stirrups, $ns_2 = 2.00$
 $h2 = 250.00$

 $Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fyw1 = 781.25$
 $fyw2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$

$ft1 = 327.9137$
 $fy1 = 273.2614$

$su1 = 0.0027982$

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

$lo/lou, min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket \cdot Asl, ten, jacket + fs_core \cdot Asl, ten, core) / Asl, ten = 273.2614$

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

$y2 = 0.00087444$

$sh2 = 0.0027982$

$ft2 = 327.9137$

$fy2 = 273.2614$

$su2 = 0.0027982$

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

$lo/lou, min = lb/lb, min = 0.14801896$

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

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.

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

with $fs2 = (fs_jacket \cdot Asl, com, jacket + fs_core \cdot Asl, com, core) / Asl, com = 273.2614$

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

$yv = 0.00087444$

$shv = 0.0027982$

$ftv = 327.9137$

$fyv = 273.2614$

$suv = 0.0027982$

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

$lo/lou, min = lb/ld = 0.14801896$

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

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 $fsv = (fs_jacket \cdot Asl, mid, jacket + fs_mid \cdot Asl, mid, core) / Asl, mid = 273.2614$

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

$1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$

$2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$

$v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 32.82751$$

$$cc (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of M_{u2} -

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

$$u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e (5.4c) = 0.02630475$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.11493$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$

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

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 $fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$

```

with Es2 = (Esjacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----
-----
-----
-----

```

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$V_{Col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$V_{Col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

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 = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 781.25

Existing Column

New material: Steel Strength, fs = 1.25*fsm = 781.25

#####

External Height, H = 450.00

External Width, W = 450.00

Internal Height, H = 250.00

Internal Width, W = 250.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.09425

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lo = 300.00

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = -2.9582284E-031

EDGE -B-

Shear Force, Vb = 2.9582284E-031

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_{lt} = 0.00$

-Compression: $As_{lc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3261E+008$

$Mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3261E+008$

$Mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.9430876E-006$

$M_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_u = 0.0099875$

we (5.4c) $= 0.02630475$

$ase ((5.4d), \text{TBDY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$

$ase1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi2_1 = 608400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi2_2 = 234256.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$

$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 450.00$

$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00049645$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, ns_2 = 2.00
h2 = 250.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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 = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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

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

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

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 32.82751$
 $cc \text{ (5A.5, TBDY)} = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.9)} = 0.23123015$
 $\mu_u = M_{Rc} \text{ (4.14)} = 1.3261E+008$
 $u = su \text{ (4.1)} = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

 Calculation of μ_{u1} -

 Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

 with full section properties:
 $b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co \text{ (5A.5, TBDY)} = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.0099875$

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

From (5.4b), TBDY: $c_u = 0.0099875$

w_e (5.4c) = 0.02630475

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.0029425$

c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

$fy_1 = 273.2614$

$su_1 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 \cdot esu_{1_nominal}$ ((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 $fsy_1 = fs_1 / 1.2$, 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 $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 273.2614$

with $Es_1 = (E_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + E_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.14801896$

```

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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00

```

$$n = 12.00$$

Calculation of Mu2+

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0099875$$

$$\phi_{we} \text{ (5.4c)} = 0.02630475$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{ase1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 3.11493$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

```

su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of μ_2 -

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

$\mu = 8.9430876\text{E-}006$

$\mu_u = 1.3261\text{E+}008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu} = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_{cu} = 0.0099875$

ϕ_{we} (5.4c) = 0.02630475

ϕ_{ase} ((5.4d), TBDY) = $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.2533421$

$\phi_{ase1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$\phi_{psh,min} \cdot F_{ywe} = \text{Min}(\phi_{psh,x} \cdot F_{ywe}, \phi_{psh,y} \cdot F_{ywe}) = 3.11493$

$\phi_{psh,x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{ps2} \cdot F_{ywe2} = 3.11493$

ϕ_{ps1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

ϕ_{ps2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$\phi_{psh,y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{ps2} \cdot F_{ywe2} = 3.11493$

$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $No \text{ stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $No \text{ stirups, } ns_2 = 2.00$
 $h2 = 250.00$

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/lb = 0.14801896

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/lb = 0.14801896

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05655989$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

$$c_c (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/d

$$\text{Lap Length: } l_b/d = 0.14801896$$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

$$\text{Calculation of Shear Strength } V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$$

$$\text{Calculation of Shear Strength at edge 1, } V_{r1} = 575966.892$$

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

$$V_{CoI0} = 575966.892$$

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

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).

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

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 \cdot h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, Vr2 = 575966.892

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

$$VCol0 = 575966.892$$

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$\mu_v = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -2.8989E+007$

Shear Force, $V_2 = -9660.785$

Shear Force, $V_3 = -8.1491463E-013$

Axial Force, $F = -7502.943$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 1137.257$

-Compression: $As_c = 1539.38$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

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

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{l,com,core} = 307.8761$

-Middle: $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04047263$

$u = y + p = 0.04047263$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00453093$ ((4.29), Biskinis Phd))

$M_y = 1.1954E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 3000.726
 From table 10.5, ASCE 41-17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7502.943$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00398711$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Lap Length: $I_d/I_{d,min} = 0.1850237$
 $I_b = 300.00$
 $I_d = 1621.414$
 Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 625.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

- Calculation of p -

From table 10-8: $p = 0.0359417$
 with:
 - Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$
 shear control ratio $V_y E / V_{col} E = 0.1534981$
 $d = d_{external} = 407.00$

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

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 450.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 250.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c,jacket} \cdot A_{jacket} + f_{c,core} \cdot A_{core}) / \text{section_area} = 30.00$$

$$f_{yE} = (f_{y,ext_Long_Reinf} \cdot A_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot A_{int_Long_Reinf}) / A_{Tot_Long_Rein} = 625.00$$

$$f_{yE} = (f_{y,ext_Trans_Reinf} \cdot A_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot A_{int_Trans_Reinf}) / A_{Tot_Trans_Rein} = 625.00$$

$$\rho_l = A_{Tot_Long_Rein} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

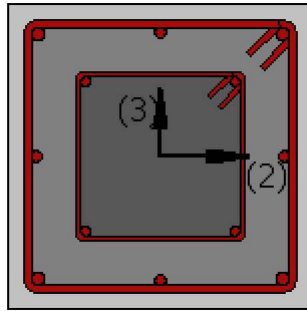
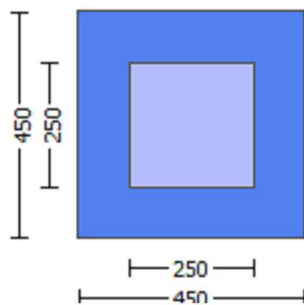
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand,

the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as

Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -2.8989E+007$

Shear Force, $V_a = -9660.785$

EDGE -B-
 Bending Moment, Mb = 0.02625938
 Shear Force, Vb = 9660.785
 BOTH EDGES
 Axial Force, F = -7502.943
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 0.00
 -Compression: Aslc = 2676.637
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1137.257
 -Compression: Asl,com = 1137.257
 -Middle: Asl,mid = 402.1239
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 464717.306
 Vn ((10.3), ASCE 41-17) = knl*VCol0 = 464717.306
 VCol = 464717.306
 knl = 1.00
 displacement_ductility_demand = 0.36371009

 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*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
 Mu = 0.02625938
 Vu = 9660.785
 d = 0.8*h = 360.00
 Nu = 7502.943
 Ag = 202500.00
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 282743.339
 where:
 Vs1 = 282743.339 is calculated for jacket, with:
 d = 360.00
 Av = 157079.633
 fy = 500.00
 s = 100.00
 Vs1 is multiplied by Col1 = 1.00
 s/d = 0.27777778
 Vs2 = 0.00 is calculated for core, with:
 d = 200.00
 Av = 100530.965
 fy = 500.00
 s = 250.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.25
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 481278.84
 bw = 450.00

 displacement_ductility_demand is calculated as / y

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

 From analysis, chord rotation = 0.00016475
 y = (My*Ls/3)/Eleff = 0.00045298 ((4.29),Biskinis Phd))
 My = 1.1954E+008
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 300.00
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.6391E+013

factor = 0.30
 Ag = 202500.00
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 N = 7502.943
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00620943$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $fc = 30.00$
 $Ec = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $Es = 200000.00$

Calculation of ratio l_b/d

Lap Length: $l_d/l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 14

column C1, Floor 1

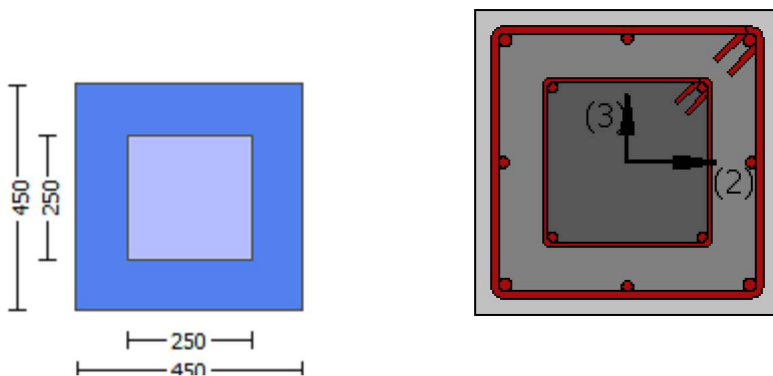
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.09425
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -1.2249986E-030$
EDGE -B-
Shear Force, $V_b = 1.2249986E-030$
BOTH EDGES
Axial Force, $F = -7506.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{c,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3261E+008$
 $\mu_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3261E+008$
 $\mu_{u2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\alpha_1 = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \alpha_1) = 0.0099875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.0099875$

```

we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.2533421
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

Asec = 202500.00

```

```

s1 = 100.00

```

```

s2 = 250.00

```

```

fywe1 = 781.25

```

```

fywe2 = 781.25

```

```

fce = 30.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.0029425

```

```

c = confinement factor = 1.09425

```

```

y1 = 0.00087444

```

```

sh1 = 0.0027982

```

```

ft1 = 327.9137

```

```

fy1 = 273.2614

```

```

su1 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb = 0.14801896

```

```

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 = 273.2614

```

```

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

```

```

y2 = 0.00087444

```

```

sh2 = 0.0027982

```

```

ft2 = 327.9137

```

```

fy2 = 273.2614

```

```

su2 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb,min = 0.14801896

```

```

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 , $sh_{2,ft2,fy2}$, it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , $sh_{1,ft1,fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 273.2614$

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

$y_v = 0.00087444$

$sh_v = 0.0027982$

$ft_v = 327.9137$

$fy_v = 273.2614$

$suv = 0.0027982$

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

$l_o/l_{ou,min} = l_b/l_d = 0.14801896$

$suv = 0.4 \cdot es_{u_nominal} ((5.5), TBDY) = 0.032$

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

with $fs_v = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.05655989$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05655989$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

$cc (5A.5, TBDY) = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.07045463$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.07045463$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

$Mu = MR_c (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of Mu1-

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.0099875$$

$$\phi_{ue} \text{ (5.4c)} = 0.02630475$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 3.11493$$

$$\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{sh,y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.11493$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$s_{h1} = 0.0027982$$

$$f_{t1} = 327.9137$$

$$f_{y1} = 273.2614$$

$$s_{u1} = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 273.2614$
with $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y_2 = 0.00087444$
 $sh_2 = 0.0027982$
 $ft_2 = 327.9137$
 $fy_2 = 273.2614$
 $su_2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 273.2614$
with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:
 $\mu = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 co (5A.5, TBDY) = 0.002
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.0099875$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\mu_u = 0.0099875$
 we (5.4c) = 0.02630475
 ase ((5.4d), TBDY) = $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.2533421$
 $ase1 = 0.2533421$
 $bo_1 = 390.00$
 $ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2$ (internal) = $(Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$
 $ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 250.00$

 $Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fyw1 = 781.25$
 $fyw2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$

$ft1 = 327.9137$
 $fy1 = 273.2614$

$su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fs1 = (fs_jacket \cdot Asl, \text{ten}, \text{jacket} + fs_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$

$sh2 = 0.0027982$

$ft2 = 327.9137$

$fy2 = 273.2614$

$su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$

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

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 $fs2 = (fs_jacket \cdot Asl, \text{com}, \text{jacket} + fs_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 273.2614$

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

$yv = 0.00087444$

$shv = 0.0027982$

$ftv = 327.9137$

$fyv = 273.2614$

$suv = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$

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

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 $fsv = (fs_jacket \cdot Asl, \text{mid}, \text{jacket} + fs_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 273.2614$

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

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$

$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 32.82751$$

$$cc (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

Calculation of M_{u2} -

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

$$u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e (5.4c) = 0.02630475$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.11493$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

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

$lo/lou, \min = lb/ld = 0.14801896$
 $su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$

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

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

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

$lo/lou, \min = lb/lb, \min = 0.14801896$
 $su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$

```

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----
-----
-----
-----

```

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

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

$V_{col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

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

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

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

$V_{col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

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

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

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 = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00

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

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 781.25

Existing Column

New material: Steel Strength, fs = 1.25*fsm = 781.25

#####

External Height, H = 450.00

External Width, W = 450.00

Internal Height, H = 250.00

Internal Width, W = 250.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.09425

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lo = 300.00

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = -2.9582284E-031

EDGE -B-

Shear Force, Vb = 2.9582284E-031

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{c,com} = 1137.257$

-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3261E+008$

$Mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3261E+008$

$Mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

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

$\phi_u = 8.9430876E-006$

$M_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_0 (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_0) = 0.0099875$

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

From (5.4b), TBDY: $\phi_u = 0.0099875$

we (5.4c) = 0.02630475

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$

$ase1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi2_1 = 608400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi2_2 = 234256.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$

$ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 450.00$

$ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00049645$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, ns_2 = 2.00
h2 = 250.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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 = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/ld = 0.14801896

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

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

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

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 32.82751$
 $cc \text{ (5A.5, TBDY)} = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.9)} = 0.23123015$
 $\mu_u = M_{Rc} \text{ (4.14)} = 1.3261E+008$
 $u = su \text{ (4.1)} = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

 Calculation of μ_{u1} -

 Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

 with full section properties:
 $b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co \text{ (5A.5, TBDY)} = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.0099875$

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

From (5.4b), TBDY: $c_u = 0.0099875$

w_e (5.4c) = 0.02630475

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.0029425$

c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

$fy_1 = 273.2614$

$su_1 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 \cdot esu_{1_nominal}$ ((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 $fsy_1 = fs_1 / 1.2$, 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 $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 273.2614$

with $Es_1 = (E_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + E_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.14801896$

$su_2 = 0.4 \cdot esu_{2_nominal} ((5.5), TBDY) = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 273.2614$
 with $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lo_{u,min} = lb/ld = 0.14801896$
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$
 with $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.01999908$

and confined core properties:

$b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

$\mu_u = MR_c (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

Calculation of ratio lb/ld

Lap Length: $lb/ld = 0.14801896$

$lb = 300.00$

$ld = 2026.767$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$$n = 12.00$$

Calculation of Mu2+

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

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0099875$$

$$\phi_{we} \text{ (5.4c)} = 0.02630475$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{ase1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.11493$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

```

su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of μ_u

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

$\mu_u = 8.9430876\text{E-}006$

$\mu_u = 1.3261\text{E+}008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_u (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u = \text{shear_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.0099875$

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

From (5.4b), TBDY: $\phi_u = 0.0099875$

ϕ_u (5.4c) = 0.02630475

ϕ_{u1} ((5.4d), TBDY) = $(\phi_{u1} \cdot A_{ext} + \phi_{u2} \cdot A_{int}) / A_{sec} = 0.2533421$

$\phi_{u1} = 0.2533421$

$b_{o1} = 390.00$

$h_{o1} = 390.00$

$b_{i2} = 608400.00$

$\phi_{u2} = \text{Max}(\phi_{u1}, \phi_{u2}) = 0.2533421$

$b_{o2} = 242.00$

$h_{o2} = 242.00$

$b_{i2} = 234256.00$

$\phi_{sh,min} \cdot F_{ywe} = \text{Min}(\phi_{sh,x} \cdot F_{ywe}, \phi_{sh,y} \cdot F_{ywe}) = 3.11493$

$\phi_{sh,x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

ϕ_{sh1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

ϕ_{sh2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$\phi_{sh,y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $No \text{ stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $No \text{ stirups, } ns_2 = 2.00$
 $h2 = 250.00$

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

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

lo/lou,min = lb/lb = 0.14801896

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

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614

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

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

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

lo/lou,min = lb/lb,min = 0.14801896

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

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

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

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

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 273.2614

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

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

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

lo/lou,min = lb/lb = 0.14801896

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

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

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

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

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

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614

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

1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05655989$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

$$c_c (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio I_b/I_d

$$\text{Lap Length: } I_b/I_d = 0.14801896$$

$$I_b = 300.00$$

$$I_d = 2026.767$$

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

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

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

$$\text{Calculation of Shear Strength } V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$$

$$\text{Calculation of Shear Strength at edge 1, } V_{r1} = 575966.892$$

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

$$V_{CoI0} = 575966.892$$

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

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).

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

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 \cdot h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, Vr2 = 575966.892

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

$$V_{Col0} = 575966.892$$

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$\mu_v = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

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

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 2.2636163E-010$

Shear Force, $V_2 = 9660.785$

Shear Force, $V_3 = 8.1491463E-013$

Axial Force, $F = -7502.943$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

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

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

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

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{l,com,core} = 307.8761$

-Middle: $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03820662$

$u = y + p = 0.03820662$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00226492$ ((4.29), Biskinis Phd))

$M_y = 1.1954E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
 From table 10.5, ASCE 41-17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7502.943$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00398711$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Lap Length: $I_d/I_{d,min} = 0.1850237$
 $I_b = 300.00$
 $I_d = 1621.414$
 Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 625.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

- Calculation of p -

From table 10-8: $p = 0.0359417$
 with:
 - Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$
 shear control ratio $V_y E / V_{col} E = 0.1534981$
 $d = d_{external} = 407.00$

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

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 450.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 250.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c_jacket} \cdot A_{\text{jacket}} + f_{c_core} \cdot A_{\text{core}}) / \text{section_area} = 30.00$$

$$f_{yE} = (f_{y_ext_Long_Reinf} \cdot A_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot A_{\text{int_Long_Reinf}}) / A_{\text{Tot_Long_Rein}} = 625.00$$

$$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot A_{\text{ext_Trans_Reinf}} + f_{y_int_Trans_Reinf} \cdot A_{\text{int_Trans_Reinf}}) / A_{\text{Tot_Trans_Rein}} = 625.00$$

$$\rho_l = A_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

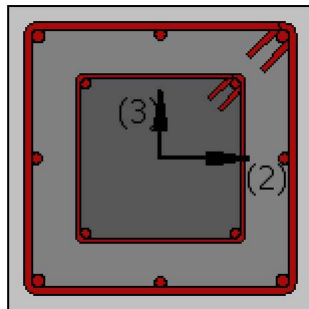
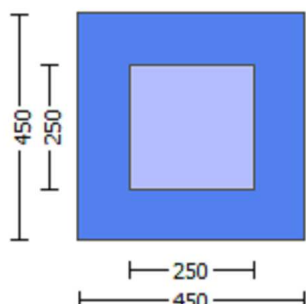
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

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, $f_c = f_{c_lower_bound} = 20.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ for displacement ductility demand, the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as Deformation-Controlled Action (Table C7-1, ASCE 41-17).

Jacket

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

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

Existing Column

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

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

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = 2.2188820E-009$

Shear Force, $V_a = -8.1491463E-013$

EDGE -B-
 Bending Moment, Mb = 2.2636163E-010
 Shear Force, Vb = 8.1491463E-013
 BOTH EDGES
 Axial Force, F = -7502.943
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 0.00
 -Compression: Aslc = 2676.637
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1137.257
 -Compression: Asl,com = 1137.257
 -Middle: Asl,mid = 402.1239
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 464717.306
 Vn ((10.3), ASCE 41-17) = knl*VCol0 = 464717.306
 VCol = 464717.306
 knl = 1.00
 displacement_ductility_demand = 0.00

 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*Area_jacket + fc'_core*Area_core)/Area_section = 20.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
 Mu = 2.2636163E-010
 Vu = 8.1491463E-013
 d = 0.8*h = 360.00
 Nu = 7502.943
 Ag = 202500.00
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 282743.339
 where:
 Vs1 = 282743.339 is calculated for jacket, with:
 d = 360.00
 Av = 157079.633
 fy = 500.00
 s = 100.00
 Vs1 is multiplied by Col1 = 1.00
 s/d = 0.27777778
 Vs2 = 0.00 is calculated for core, with:
 d = 200.00
 Av = 100530.965
 fy = 500.00
 s = 250.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.25
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 481278.84
 bw = 450.00

 displacement_ductility_demand is calculated as / y

- Calculation of / y for END B -
 for rotation axis 2 and integ. section (b)

 From analysis, chord rotation = 1.0020439E-020
 y = (My*Ls/3)/Eleff = 0.00226492 ((4.29),Biskinis Phd))
 My = 1.1954E+008
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.6391E+013

factor = 0.30
 Ag = 202500.00
 Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 N = 7502.943
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00620943$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $" = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $fc = 30.00$
 $Ec = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $Es = 200000.00$

Calculation of ratio l_b/d

Lap Length: $l_d/l_{d,min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 625.00$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 16

column C1, Floor 1

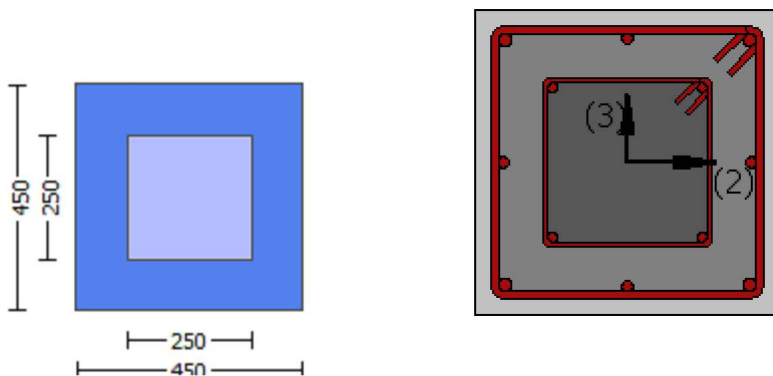
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 781.25$

#####

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$
Mean Confinement Factor overall section = 1.09425
Element Length, $L = 3000.00$
Primary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $l_o = 300.00$
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -1.2249986E-030$
EDGE -B-
Shear Force, $V_b = 1.2249986E-030$
BOTH EDGES
Axial Force, $F = -7506.808$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 2676.637$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1137.257$
-Compression: $As_{c,com} = 1137.257$
-Middle: $As_{mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3261E+008$
 $\mu_{u1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3261E+008$
 $\mu_{u2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $\mu_{u2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $\alpha = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha) = 0.00999875$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.00999875$

```

we (5.4c) = 0.02630475
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.2533421
ase1 = 0.2533421
bo_1 = 390.00
ho_1 = 390.00
bi2_1 = 608400.00
ase2 = Max(ase1,ase2) = 0.2533421
bo_2 = 242.00
ho_2 = 242.00
bi2_2 = 234256.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.11493

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

```

```

Asec = 202500.00

```

```

s1 = 100.00

```

```

s2 = 250.00

```

```

fywe1 = 781.25

```

```

fywe2 = 781.25

```

```

fce = 30.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.0029425

```

```

c = confinement factor = 1.09425

```

```

y1 = 0.00087444

```

```

sh1 = 0.0027982

```

```

ft1 = 327.9137

```

```

fy1 = 273.2614

```

```

su1 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb = 0.14801896

```

```

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 = 273.2614

```

```

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

```

```

y2 = 0.00087444

```

```

sh2 = 0.0027982

```

```

ft2 = 327.9137

```

```

fy2 = 273.2614

```

```

su2 = 0.0027982

```

```

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

```

```

lo/lou,min = lb/lb,min = 0.14801896

```

```

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 $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 273.2614$

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

$y_v = 0.00087444$

$sh_v = 0.0027982$

$ft_v = 327.9137$

$fy_v = 273.2614$

$s_{uv} = 0.0027982$

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

$l_o/l_{ou,min} = l_b/l_d = 0.14801896$

$s_{uv} = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

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

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

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

with $fs_v = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

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

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.05655989$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05655989$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

$cc (5A.5, TBDY) = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$1 = A_{sl,ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.07045463$

$2 = A_{sl,com}/(b \cdot d) \cdot (fs_2/f_c) = 0.07045463$

$v = A_{sl,mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

$Mu = MR_c (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

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

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

= 1

$db = 16.66667$

Mean strength value of all re-bars: $fy = 781.25$

Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $fc'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

Calculation of Mu1-

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

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{1,nominal} = 0.08$,
For calculation of $esu_{1,nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 273.2614$
with $Es_1 = (Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$
 $y_2 = 0.00087444$
 $sh_2 = 0.0027982$
 $ft_2 = 327.9137$
 $fy_2 = 273.2614$
 $su_2 = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_2, sh_2, ft_2, fy_2 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 273.2614$
with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $y_v = 0.00087444$
 $sh_v = 0.0027982$
 $ft_v = 327.9137$
 $fy_v = 273.2614$
 $suv = 0.0027982$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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 $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 273.2614$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.05655989$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05655989$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.01999908$
and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 32.82751$
 $cc (5A.5, TBDY) = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07045463$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07045463$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.02491213$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
--->
 $su (4.9) = 0.23123015$
 $Mu = MRc (4.14) = 1.3261E+008$
 $u = su (4.1) = 8.9430876E-006$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$
 $l_b = 300.00$
 $l_d = 2026.767$
 Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

Calculation of μ_{2+}

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

$\mu = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu} = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.0099875$

we (5.4c) = 0.02630475

$\phi_{ase} ((5.4d), \text{TBDY}) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.2533421$

$ase1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi2_1 = 608400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi2_2 = 234256.00$

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$

$ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = A_{stir_1} \cdot ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h1 = 450.00$

$ps2$ (internal) = $(Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$

$Ash2 = A_{stir_2} \cdot ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

$h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$

$ps1$ (external) = $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 250.00$

 $Asec = 202500.00$

$s1 = 100.00$

$s2 = 250.00$

$fyw1 = 781.25$

$fyw2 = 781.25$

$fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$

$sh1 = 0.0027982$

$ft1 = 327.9137$

$fy1 = 273.2614$

$su1 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, \min = lb/ld = 0.14801896$

$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs_jacket \cdot Asl, \text{ten}, \text{jacket} + fs_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 273.2614$

with $Es1 = (Es_jacket \cdot Asl, \text{ten}, \text{jacket} + Es_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$

$y2 = 0.00087444$

$sh2 = 0.0027982$

$ft2 = 327.9137$

$fy2 = 273.2614$

$su2 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, \min = lb/lb, \min = 0.14801896$

$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs_jacket \cdot Asl, \text{com}, \text{jacket} + fs_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 273.2614$

with $Es2 = (Es_jacket \cdot Asl, \text{com}, \text{jacket} + Es_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$

$yv = 0.00087444$

$shv = 0.0027982$

$ftv = 327.9137$

$fyv = 273.2614$

$suv = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, \min = lb/ld = 0.14801896$

$suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fsv = (fs_jacket \cdot Asl, \text{mid}, \text{jacket} + fs_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 273.2614$

with $Esv = (Es_jacket \cdot Asl, \text{mid}, \text{jacket} + Es_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$

$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$

$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 32.82751$$

$$cc \text{ (5A.5, TBDY)} = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u \text{ (4.9)} = 0.23123015$$

$$M_u = M_{Rc} \text{ (4.14)} = 1.3261E+008$$

$$u = s_u \text{ (4.1)} = 8.9430876E-006$$

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$$l_b = 300.00$$

$$l_d = 2026.767$$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00, \text{ but } f_c'^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$$

$$n = 12.00$$

Calculation of M_u2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_o) = 0.0099875$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$ho_1 = 390.00$
 $bi2_1 = 608400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$
 $bo_2 = 242.00$
 $ho_2 = 242.00$
 $bi2_2 = 234256.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 3.11493$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.11493$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00349066$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 450.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00049645$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 250.00$

$Asec = 202500.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fywe1 = 781.25$
 $fywe2 = 781.25$
 $fce = 30.00$

From ((5.A5), TBDY), TBDY: $cc = 0.0029425$
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$
 $sh1 = 0.0027982$
 $ft1 = 327.9137$
 $fy1 = 273.2614$
 $su1 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, \min = lb/ld = 0.14801896$

$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$

with $Es1 = (Es, \text{jacket} * Asl, \text{ten, jacket} + Es, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$

$y2 = 0.00087444$
 $sh2 = 0.0027982$
 $ft2 = 327.9137$
 $fy2 = 273.2614$
 $su2 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lou, \min = lb/lb, \min = 0.14801896$

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$

```

with Es2 = (Esjacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00
n = 12.00
-----
-----
-----
-----

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Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

Calculation of Shear Strength at edge 1, $V_{r1} = 575966.892$

$V_{r1} = V_{col} \text{ ((10.3), ASCE 41-17)} = knl * V_{col0}$

$V_{col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

$A_v = 100530.965$

$f_y = 625.00$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 1.25$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 589443.792$

$bw = 450.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 575966.892$

$V_{r2} = V_{col} \text{ ((10.3), ASCE 41-17)} = knl * V_{col0}$

$V_{col0} = 575966.892$

$knl = 1$ (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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 8.8568787E-012$

$\nu_u = 1.2249986E-030$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 353429.174$

where:

$V_{s1} = 353429.174$ is calculated for jacket, with:

$d = 360.00$

$A_v = 157079.633$

$f_y = 625.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.27777778$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 200.00$

Av = 100530.965

fy = 625.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.25

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 589443.792

bw = 450.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

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 = 30.00

New material of Primary Member: Steel Strength, fs = fsm = 625.00

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

Existing Column

New material of Primary Member: Concrete Strength, fc = fcm = 30.00

New material of Primary Member: Steel Strength, fs = fsm = 625.00

Concrete Elasticity, Ec = 25742.96

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 781.25

Existing Column

New material: Steel Strength, fs = 1.25*fsm = 781.25

#####

External Height, H = 450.00

External Width, W = 450.00

Internal Height, H = 250.00

Internal Width, W = 250.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.09425

Element Length, L = 3000.00

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lo = 300.00

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = -2.9582284E-031

EDGE -B-

Shear Force, Vb = 2.9582284E-031

BOTH EDGES

Axial Force, $F = -7506.808$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_{lt} = 0.00$

-Compression: $As_{lc} = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{l,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

-Middle: $As_{l,mid} = 402.1239$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.1534981$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 88409.826$ with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3261E+008$

$Mu_{1+} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3261E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3261E+008$

$Mu_{2+} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3261E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.9430876E-006$

$M_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_0 (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_0) = 0.0099875$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.0099875$

we (5.4c) = 0.02630475

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$

$ase1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi2_1 = 608400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi2_2 = 234256.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$

$ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00349066$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirrups, $ns_1 = 2.00$

$h1 = 450.00$

$ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00049645$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, ns_2 = 2.00
h2 = 250.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.11493
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00349066
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 450.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00049645
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 250.00

Asec = 202500.00

s1 = 100.00

s2 = 250.00

fywe1 = 781.25

fywe2 = 781.25

fce = 30.00

From ((5.A5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y1 = 0.00087444

sh1 = 0.0027982

ft1 = 327.9137

fy1 = 273.2614

su1 = 0.0027982

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.14801896

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 = 273.2614

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00087444

sh2 = 0.0027982

ft2 = 327.9137

fy2 = 273.2614

su2 = 0.0027982

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 0.14801896

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 = 273.2614

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.00087444

shv = 0.0027982

ftv = 327.9137

fyv = 273.2614

suv = 0.0027982

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 0.14801896

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$
 with $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$
 and confined core properties:
 $b = 390.00$
 $d = 377.00$
 $d' = 13.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 32.82751$
 $cc \text{ (5A.5, TBDY)} = 0.0029425$
 $c = \text{confinement factor} = 1.09425$
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is satisfied
 --->
 $su \text{ (4.9)} = 0.23123015$
 $\mu_u = M_{Rc} \text{ (4.14)} = 1.3261E+008$
 $u = su \text{ (4.1)} = 8.9430876E-006$

 Calculation of ratio lb/ld

 Lap Length: $lb/ld = 0.14801896$
 $lb = 300.00$
 $ld = 2026.767$
 Calculation of lb_{min} according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 ld_{min} from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 781.25$
 Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$
 where $A_{tr,x}, A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

 Calculation of μ_{u1} -

 Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.9430876E-006$
 $\mu_u = 1.3261E+008$

 with full section properties:
 $b = 450.00$
 $d = 407.00$
 $d' = 43.00$
 $v = 0.00136624$
 $N = 7506.808$
 $f_c = 30.00$
 $co \text{ (5A.5, TBDY)} = 0.002$
 Final value of μ_u : $\mu_u^* = \text{shear_factor} \cdot \text{Max}(\mu_u, cc) = 0.0099875$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.0099875$

w_e (5.4c) = 0.02630475

a_{se} ((5.4d), TBDY) = $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$

p_{s1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

p_{s2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.0029425$

c = confinement factor = 1.09425

$y_1 = 0.00087444$

$sh_1 = 0.0027982$

$ft_1 = 327.9137$

$fy_1 = 273.2614$

$su_1 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 \cdot esu_{1_nominal}$ ((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 $fsy_1 = fs_1 / 1.2$, 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 $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 273.2614$

with $Es_1 = (E_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + E_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.14801896$

```

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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006
-----

Calculation of ratio lb/ld
-----
Lap Length: lb/ld = 0.14801896
lb = 300.00
ld = 2026.767
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
= 1
db = 16.66667
Mean strength value of all re-bars: fy = 781.25
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 30.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 3.43481
Atr = Min(Atr_x,Atr_y) = 257.6106
where Atr_x, Atr_y are the sum of the area of all stirrup legs along X and Y loxal axis
s = Max(s_external,s_internal) = 250.00

```

$$n = 12.00$$

Calculation of Mu2+

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 8.9430876E-006$$

$$M_u = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

$$\phi_{co} \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.0099875$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.0099875$$

$$\phi_{we} \text{ (5.4c)} = 0.02630475$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\phi_{ase1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$$

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 3.11493$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.11493$$

$$\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 450.00$$

$$\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.0029425$$

$$\phi_c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$


```

su1 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00087444
sh2 = 0.0027982
ft2 = 327.9137
fy2 = 273.2614
su2 = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.14801896
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 = 273.2614
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00087444
shv = 0.0027982
ftv = 327.9137
fyv = 273.2614
suv = 0.0027982
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.14801896
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 = 273.2614
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989
2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989
v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908
and confined core properties:
b = 390.00
d = 377.00
d' = 13.00
fcc (5A.2, TBDY) = 32.82751
cc (5A.5, TBDY) = 0.0029425
c = confinement factor = 1.09425
1 = Asl,ten/(b*d)*(fs1/fc) = 0.07045463
2 = Asl,com/(b*d)*(fs2/fc) = 0.07045463
v = Asl,mid/(b*d)*(fsv/fc) = 0.02491213
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.23123015
Mu = MRc (4.14) = 1.3261E+008
u = su (4.1) = 8.9430876E-006

```

Calculation of ratio l_b/l_d

Lap Length: $l_b/l_d = 0.14801896$

$l_b = 300.00$

$l_d = 2026.767$

Calculation of l_b ,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d ,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$= 1$

$db = 16.66667$

Mean strength value of all re-bars: $f_y = 781.25$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 12.00$

Calculation of μ_2

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876\text{E-}006$

$\mu_u = 1.3261\text{E+}008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_{cu} : $\phi_{cu} = \text{shear_factor} \cdot \text{Max}(\phi_{cu}, \phi_c) = 0.0099875$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.0099875$

ϕ_{we} (5.4c) = 0.02630475

ϕ_{ase} ((5.4d), TBDY) = $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.2533421$

$\phi_{ase1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

$\phi_{psh,min} \cdot F_{ywe} = \text{Min}(\phi_{psh,x} \cdot F_{ywe}, \phi_{psh,y} \cdot F_{ywe}) = 3.11493$

$\phi_{psh,x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{ps2} \cdot F_{ywe2} = 3.11493$

ϕ_{ps1} (external) = $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 450.00$

ϕ_{ps2} (internal) = $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 250.00$

$\phi_{psh,y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{ps2} \cdot F_{ywe2} = 3.11493$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 450.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

$$\text{From } ((5A5), \text{ TBDY}), \text{ TBDY: } cc = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 0.14801896$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$$

$$\text{with } Es1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 0.14801896$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

For calculation of $esu2_{\text{nominal}}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 273.2614$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 0.14801896$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{\text{nominal}}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 273.2614$$

$$\text{with } Esv = (Es_{\text{jacket}} \cdot Asl, \text{mid, jacket} + Es_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.05655989$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05655989$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

$$c_c (5A.5, TBDY) = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23123015$$

$$M_u = M_{Rc} (4.14) = 1.3261E+008$$

$$u = s_u (4.1) = 8.9430876E-006$$

Calculation of ratio l_b/d

$$\text{Lap Length: } l_b/d = 0.14801896$$

$$l_b = 300.00$$

$$l_d = 2026.767$$

Calculation of l_b, \min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

l_d, \min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$$

where $A_{tr,x}$, $A_{tr,y}$ are the sum of the area of all stirrup legs along X and Y loxal axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 12.00$$

$$\text{Calculation of Shear Strength } V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$$

$$\text{Calculation of Shear Strength at edge 1, } V_{r1} = 575966.892$$

$$V_{r1} = V_{CoI} ((10.3), \text{ASCE 41-17}) = k_{nl} \cdot V_{CoI0}$$

$$V_{CoI0} = 575966.892$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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).

$$= 1 \text{ (normal-weight concrete)}$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 30.00, \text{ but } f'_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 \cdot h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

Calculation of Shear Strength at edge 2, Vr2 = 575966.892

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

$$V_{Col0} = 575966.892$$

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: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$\mu_v = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 353429.174

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.27777778$$

Vs2 = 0.00 is calculated for core, with:

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.25$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 589443.792

$$bw = 450.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

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, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Primary Member: Concrete Strength, $f_c = f_{cm} = 30.00$

New material of Primary Member: Steel Strength, $f_s = f_{sm} = 625.00$

Concrete Elasticity, $E_c = 25742.96$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 450.00$

External Width, $W = 450.00$

Internal Height, $H = 250.00$

Internal Width, $W = 250.00$

Cover Thickness, $c = 25.00$

Element Length, $L = 3000.00$

Primary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 0.02625938$

Shear Force, $V_2 = 9660.785$

Shear Force, $V_3 = 8.1491463E-013$

Axial Force, $F = -7502.943$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 2676.637$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1137.257$

-Compression: $As_{l,com} = 1137.257$

-Middle: $As_{l,mid} = 402.1239$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

-Compression: $As_{l,com,jacket} = 829.3805$

-Middle: $As_{l,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 307.8761$

-Compression: $As_{l,com,core} = 307.8761$

-Middle: $As_{l,mid,core} = 0.00$

Mean Diameter of Tension Reinforcement, $Db_L = 16.80$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.03639469$

$u = y + p = 0.03639469$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00045298$ ((4.29), Biskinis Phd))

$M_y = 1.1954E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
 From table 10.5, ASCE 41-17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.6391E+013$
 $factor = 0.30$
 $A_g = 202500.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$
 $N = 7502.943$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 8.7969E+013$

Calculation of Yielding Moment M_y

Calculation of ρ_y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.2170387E-006$
 with ((10.1), ASCE 41-17) $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 253.6734$
 $d = 407.00$
 $y = 0.26100253$
 $A = 0.01477594$
 $B = 0.00824073$
 with $pt = 0.00398711$
 $pc = 0.00620943$
 $pv = 0.0021956$
 $N = 7502.943$
 $b = 450.00$
 $\rho = 0.10565111$
 $y_{comp} = 1.9895870E-005$
 with $f_c = 30.00$
 $E_c = 25742.96$
 $y = 0.25904663$
 $A = 0.01451681$
 $B = 0.00807924$
 with $E_s = 200000.00$

Calculation of ratio I_b/I_d

Lap Length: $I_d/I_{d,min} = 0.1850237$
 $I_b = 300.00$
 $I_d = 1621.414$
 Calculation of I according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
 $I_{d,min}$ from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
 $= 1$
 $db = 16.66667$
 Mean strength value of all re-bars: $f_y = 625.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)
 $t = 1.00$
 $s = 0.80$
 $e = 1.00$
 $cb = 25.00$
 $K_{tr} = 3.43481$
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$
 where A_{tr_x} , A_{tr_y} are the sum of the area of all stirrup legs along X and Y loxal axis
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$
 $n = 12.00$

- Calculation of ρ_p -

From table 10-8: $\rho_p = 0.0359417$
 with:
 - Columns controlled by inadequate development or splicing along the clear height because $I_b/I_d < 1$
 shear control ratio $V_y E / V_{col} E = 0.1534981$
 $d = d_{external} = 407.00$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00398711$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00349066$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 450.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00049645$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 250.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c_jacket} \cdot A_{\text{jacket}} + f_{c_core} \cdot A_{\text{core}}) / \text{section_area} = 30.00$$

$$f_{yE} = (f_{y_ext_Long_Reinf} \cdot A_{\text{ext_Long_Reinf}} + f_{y_int_Long_Reinf} \cdot A_{\text{int_Long_Reinf}}) / A_{\text{Tot_Long_Rein}} = 625.00$$

$$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot A_{\text{ext_Trans_Reinf}} + f_{y_int_Trans_Reinf} \cdot A_{\text{int_Trans_Reinf}}) / A_{\text{Tot_Trans_Rein}} = 625.00$$

$$\rho_l = A_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)
