

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

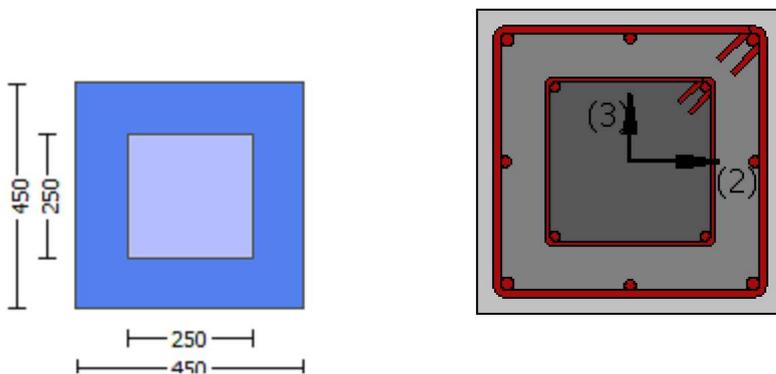
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column 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, 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
#####
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
#####
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 = -1.8336E+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: Asc = 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 = 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).
-----
= 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)

```

$M/Vd = 4.00$   
 $\mu = 1.8336E+007$   
 $V_u = 6110.425$   
 $d = 0.8 \cdot h = 360.00$   
 $N_u = 7504.363$   
 $A_g = 202500.00$   
 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  $\delta / y$

- Calculation of  $\delta / y$  for END A -  
 for rotation axis 3 and integ. section (a)

-----  
 From analysis, chord rotation  $\theta = 0.00019823$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00453094$  ((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  $\delta / y$  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)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 253.6734$   
 $d = 407.00$   
 $y = 0.261003$   
 $A = 0.01477597$   
 $B = 0.00824076$   
 with  $pt = 0.00620943$   
 $pc = 0.00620943$   
 $pv = 0.0021956$   
 $N = 7504.363$   
 $b = 450.00$   
 $\lambda = 0.10565111$   
 $y_{comp} = 1.9895862E-005$   
 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 lb/l<sub>d</sub>

Lap Length: l<sub>d</sub>/l<sub>d,min</sub> = 0.1850237

l<sub>b</sub> = 300.00

l<sub>d</sub> = 1621.414

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

l<sub>d,min</sub> 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<sub>y</sub> = 625.00

Mean concrete strength: f<sub>c</sub>' = (f<sub>c</sub>'<sub>jacket</sub>\*Area<sub>jacket</sub> + f<sub>c</sub>'<sub>core</sub>\*Area<sub>core</sub>)/Area<sub>section</sub> = 30.00, but f<sub>c</sub>'<sup>0.5</sup> ≤ 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 3.43481

A<sub>tr</sub> = Min(A<sub>tr\_x</sub>, A<sub>tr\_y</sub>) = 257.6106

where A<sub>tr\_x</sub>, A<sub>tr\_y</sub> are the sum of the area of all stirrup legs along X and Y local axis

s = Max(s<sub>external</sub>, s<sub>internal</sub>) = 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

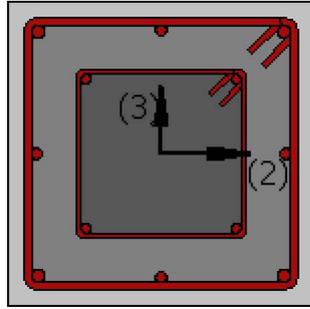
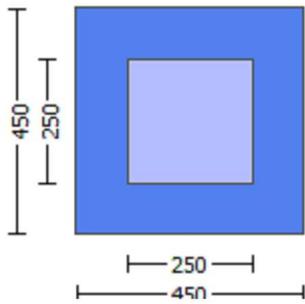
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

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,  $f_s = 1.25 * f_{sm} = 781.25$

Existing Column

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

#####

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:  $As_{,ten} = 1137.257$   
-Compression:  $As_{,com} = 1137.257$   
-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  $\phi_u$  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, TBDY) = 0.002

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)

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

$\phi_u$  (5.4c) = 0.02630475

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

$\phi_{u,ase1} = 0.2533421$

$\phi_{u,bo_1} = 390.00$

$\phi_{u,ho_1} = 390.00$

$\phi_{u,bi_2_1} = 608400.00$

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

$\phi_{u,bo_2} = 242.00$

$\phi_{u,ho_2} = 242.00$

$\phi_{u,bi_2_2} = 234256.00$

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

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

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

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

No stirups,  $n_{s_1} = 2.00$

$h_1 = 450.00$

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

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

No stirups,  $n_{s_2} = 2.00$

$$h2 = 250.00$$

$$\begin{aligned} psh\_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 3.11493 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00349066 \\ Ash1 &= Astir\_1 * ns\_1 = 157.0796 \\ \text{No stirups, } ns\_1 &= 2.00 \\ h1 &= 450.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00049645 \\ Ash2 &= Astir\_2 * ns\_2 = 100.531 \\ \text{No stirups, } ns\_2 &= 2.00 \\ h2 &= 250.00 \end{aligned}$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

$$su1 = 0.4 * esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08,$$

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

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

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.14801896$$

$$su2 = 0.4 * esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2\_nominal = 0.08,$$

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

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

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

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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

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

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:

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$\mu_u (4.9) = 0.23123015$   
 $\mu_u = M_{Rc} (4.14) = 1.3261E+008$   
 $u = \mu_u (4.1) = 8.9430876E-006$

-----  
Calculation of ratio  $l_b/d$

-----  
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)

$= 1$   
 $db = 16.66667$   
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 local axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 12.00$

-----  
Calculation of  $\mu_{u1}$ -

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.9430876E-006$   
 $\mu_u = 1.3261E+008$

-----  
with full section properties:

$b = 450.00$   
 $d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $f_c = 30.00$   
 $cc (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, cc) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.0099875$   
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  
 $psh_{min} \cdot Fy_{we} = \text{Min}(psh_x \cdot Fy_{we}, psh_y \cdot Fy_{we}) = 3.11493$

-----  
 $psh_x \cdot Fy_{we} = psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2} = 3.11493$   
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

-----  
 $psh_y \cdot Fy_{we} = psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2} = 3.11493$   
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

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

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

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

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

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

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

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

From table 5A.1, TBDY:  $es_{u2\_nominal} = 0.08$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

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

$lo/lo_{u,min} = lb/d = 0.14801896$

$suv = 0.4 \cdot es_{uv\_nominal}$  ((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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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  $Es_v = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.01999908$

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

$c$  = confinement factor = 1.09425

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.02491213$

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  $lb/d$

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:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$ , 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

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

$n = 12.00$

Calculation of Mu2+

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

$$l_0/l_{ou,min} = l_b/l_d = 0.14801896$$

$$s_u1 = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08$ ,

For calculation of  $e_{su1,nominal}$  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.

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

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

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

$$y_2 = 0.00087444$$

$$sh_2 = 0.0027982$$

$$ft_2 = 327.9137$$

$$fy_2 = 273.2614$$

$$s_u2 = 0.0027982$$

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

$$l_0/l_{ou,min} = l_b/l_{b,min} = 0.14801896$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08$ ,

For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

$y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 273.2614$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s,com,jacket} + E_{s,core} * A_{s,com,core}) / A_{s,com} = 200000.00$$

$$y_v = 0.00087444$$

$$sh_v = 0.0027982$$

$$ft_v = 327.9137$$

$$fy_v = 273.2614$$

$$s_{uv} = 0.0027982$$

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

$$l_0/l_{ou,min} = l_b/l_d = 0.14801896$$

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

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

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

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

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05655989$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05655989$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

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

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

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

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

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

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)

$= 1$

$db = 16.66667$

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  $\mu_2$

Calculation of ultimate curvature  $\mu$  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  $\mu_u$ :  $\mu_u = shear\_factor \cdot \max(\mu_u, \mu_c) = 0.0099875$

The  $shear\_factor$  is considered equal to 1 (pure moment strength)

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

$w_e$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \max(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

$psh, \min \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(Ash_2 \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$Ash_2 = Astir_2 \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h_2 = 250.00$

$psh_y \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$$\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$$

$$\text{No stirups, ns}_1 = 2.00$$

$$h1 = 450.00$$

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

$$\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$$

$$\text{No stirups, ns}_2 = 2.00$$

$$h2 = 250.00$$

---

$$\text{Asec} = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$\text{fywe1} = 781.25$$

$$\text{fywe2} = 781.25$$

$$\text{fce} = 30.00$$

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

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

$$y1 = 0.00087444$$

$$\text{sh1} = 0.0027982$$

$$\text{ft1} = 327.9137$$

$$\text{fy1} = 273.2614$$

$$\text{su1} = 0.0027982$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 0.14801896$$

$$\text{su1} = 0.4 * \text{esu1\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu1\_nominal} = 0.08,$$

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

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

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

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

$$y2 = 0.00087444$$

$$\text{sh2} = 0.0027982$$

$$\text{ft2} = 327.9137$$

$$\text{fy2} = 273.2614$$

$$\text{su2} = 0.0027982$$

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

$$\text{lo/lou,min} = \text{lb/lb,min} = 0.14801896$$

$$\text{su2} = 0.4 * \text{esu2\_nominal} ((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: esu2\_nominal} = 0.08,$$

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

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

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

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

$$yv = 0.00087444$$

$$\text{shv} = 0.0027982$$

$$\text{ftv} = 327.9137$$

$$\text{fyv} = 273.2614$$

$$\text{suv} = 0.0027982$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 0.14801896$$

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

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

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

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

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

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

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

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

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

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

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

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

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

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

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  $l_b/l_d$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

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

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

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

$$V_{Co10} = 575966.892$$

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

-----  
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 (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)

$$M/Vd = 2.00$$

$$M_u = 8.8568787E-012$$

$$V_u = 1.2249986E-030$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

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

where:

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/d = 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,  $\gamma = 1.00$

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: 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 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 the static loading combination

-----  
Calculation of Mu1+  
-----

-----  
Calculation of ultimate curvature  $\phi_u$  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

fc = 30.00

co (5A.5, TBDY) = 0.002

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)

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

we (5.4c) = 0.02630475

ase ((5.4d), TBDY) =  $(\text{ase1} * \text{Aext} + \text{ase2} * \text{Aint}) / \text{Asec} = 0.2533421$

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

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirups, ns\_1 = 2.00

h1 = 450.00

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

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

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirups, ns\_1 = 2.00

h1 = 450.00

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

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:  $\phi_c = 0.0029425$

$c = \text{confinement factor} = 1.09425$   
 $y1 = 0.00087444$   
 $sh1 = 0.0027982$   
 $ft1 = 327.9137$   
 $fy1 = 273.2614$   
 $su1 = 0.0027982$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.14801896$   
 $su1 = 0.4 * esu1\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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.  
 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.14801896$   
 $su2 = 0.4 * esu2\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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.  
 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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.  
 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:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $fcc (5A.2, \text{TBDY}) = 32.82751$   
 $cc (5A.5, \text{TBDY}) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07045463$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.07045463$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - 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*Areajacket + fc'core*Areacore)/Areasection = 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(sexternal, sinternal) = 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.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/l\_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/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/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/l\_d)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 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/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  $f_{sv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 273.2614$

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:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

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

---->

$\mu_u (4.9) = 0.23123015$

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

$u = \mu_u (4.1) = 8.9430876E-006$

-----  
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

$db = 16.66667$

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 local axis

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

$n = 12.00$

-----  
Calculation of  $\mu_{u2+}$

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.9430876E-006$

$M_u = 1.3261E+008$

-----  
with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of  $cu^*$  = 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) = ( $ase1 \cdot A_{ext} + ase2 \cdot A_{int}$ )/ $A_{sec}$  = 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  
 $psh_{min} \cdot Fy_{we}$  = Min( $psh_x \cdot Fy_{we}$ ,  $psh_y \cdot Fy_{we}$ ) = 3.11493

-----  
 $psh_x \cdot Fy_{we}$  =  $psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2}$  = 3.11493  
 $ps1$  (external) = ( $A_{sh1} \cdot h1 / s1$ )/ $A_{sec}$  = 0.00349066  
 $A_{sh1}$  =  $A_{stir_1} \cdot ns_1$  = 157.0796  
 No stirups,  $ns_1$  = 2.00  
 $h1$  = 450.00  
 $ps2$  (internal) = ( $A_{sh2} \cdot h2 / s2$ )/ $A_{sec}$  = 0.00049645  
 $A_{sh2}$  =  $A_{stir_2} \cdot ns_2$  = 100.531  
 No stirups,  $ns_2$  = 2.00  
 $h2$  = 250.00

-----  
 $psh_y \cdot Fy_{we}$  =  $psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2}$  = 3.11493  
 $ps1$  (external) = ( $A_{sh1} \cdot h1 / s1$ )/ $A_{sec}$  = 0.00349066  
 $A_{sh1}$  =  $A_{stir_1} \cdot ns_1$  = 157.0796  
 No stirups,  $ns_1$  = 2.00  
 $h1$  = 450.00  
 $ps2$  (internal) = ( $A_{sh2} \cdot h2 / s2$ )/ $A_{sec}$  = 0.00049645  
 $A_{sh2}$  =  $A_{stir_2} \cdot ns_2$  = 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

$lo/lou_{min}$  =  $lb/ld$  = 0.14801896

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

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

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

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

with  $fs1$  = ( $fs_{jacket} \cdot A_{s1,ten,jacket} + fs_{core} \cdot A_{s1,ten,core}$ )/ $A_{s1,ten}$  = 273.2614

with  $Es1$  = ( $Es_{jacket} \cdot A_{s1,ten,jacket} + Es_{core} \cdot A_{s1,ten,core}$ )/ $A_{s1,ten}$  = 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

$$l_0/l_{0u,min} = l_b/l_{b,min} = 0.14801896$$

$$s_u2 = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{su2,nominal} = 0.08,$$

For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

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

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s1,com,jacket} + f_{s,core} * A_{s1,com,core}) / A_{s1,com} = 273.2614$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s1,com,jacket} + E_{s,core} * A_{s1,com,core}) / A_{s1,com} = 200000.00$$

$$y_v = 0.00087444$$

$$sh_v = 0.0027982$$

$$ft_v = 327.9137$$

$$fy_v = 273.2614$$

$$s_{uv} = 0.0027982$$

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

$$l_0/l_{0u,min} = l_b/l_d = 0.14801896$$

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

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

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

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

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

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

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

$$1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.05655989$$

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.05655989$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

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

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

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

$$2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.07045463$$

$$v = A_{s1,mid} / (b * d) * (f_{sv} / f_c) = 0.02491213$$

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)

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

Calculation of Mu2-

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.9430876E-006$$

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

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$f_{y1} = 273.2614$   
 $s_{u1} = 0.0027982$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$   
 $s_{u1} = 0.4 * e_{su1,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08$ ,  
 For calculation of  $e_{su1,nominal}$  and  $y_1, sh_1, ft_1, f_{y1}$ , it is considered  
 characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s1} = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 273.2614$   
 with  $E_{s1} = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$   
 $y_2 = 0.00087444$   
 $sh_2 = 0.0027982$   
 $ft_2 = 327.9137$   
 $f_{y2} = 273.2614$   
 $s_{u2} = 0.0027982$   
 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  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.14801896$   
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{su2,nominal} = 0.08$ ,  
 For calculation of  $e_{su2,nominal}$  and  $y_2, sh_2, ft_2, f_{y2}$ , it is considered  
 characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, f_{y2}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{s2} = (f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 273.2614$   
 with  $E_{s2} = (E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$   
 $y_v = 0.00087444$   
 $sh_v = 0.0027982$   
 $ft_v = 327.9137$   
 $f_{y_v} = 273.2614$   
 $s_{u_v} = 0.0027982$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$   
 $s_{u_v} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,  
 considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv,nominal}$  and  $y_v, sh_v, ft_v, f_{y_v}$ , it is considered  
 characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 with  $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.05655989$   
 $2 = A_{s2,com} / (b * d) * (f_{s2} / f_c) = 0.05655989$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.07045463$   
 $2 = A_{s2,com} / (b * d) * (f_{s2} / f_c) = 0.07045463$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.02491213$   
 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  $l_b/d$

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)

$= 1$

$d_b = 16.66667$

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 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,  $V_{r1} = 575966.892$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 575966.892$

$k_{nl} = 1$  (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)

$M/d = 2.00$

$M_u = 2.0434592E-012$

$V_u = 2.9582284E-031$

$d = 0.8 \cdot h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

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  $Col2 = 0.00$

$s/d = 1.25$

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

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

$b_w = 450.00$

Calculation of Shear Strength at edge 2,  $Vr2 = 575966.892$

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

$VColO = 575966.892$

$knl = 1$  (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  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$Mu = 2.0434592E-012$

$Vu = 2.9582284E-031$

$d = 0.8 * h = 360.00$

$Nu = 7506.808$

$Ag = 202500.00$

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:  $Vs + Vf \leq 589443.792$

$bw = 450.00$

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,  $fc = fcm = 30.00$

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  $l_b$  = 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:  $A_{st,mid}$  = 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:  $A_{st,mid,jacket}$  = 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:  $A_{st,mid,core}$  = 0.00  
Mean Diameter of Tension Reinforcement,  $D_bL$  = 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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$   
 $N = 7504.363$   
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 8.7969E+013$   
-----

-----  
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)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 253.6734$   
 $d = 407.00$   
 $y = 0.261003$   
 $A = 0.01477597$

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:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 30.00$ , 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 local axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 12.00$

-----  
 - Calculation of  $\rho$  -

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

with:

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

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

$d = d_{external} = 407.00$

$s = s_{external} = 0.00$

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

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.

$N_{UD} = 7504.363$

$A_g = 202500.00$

$f_c E = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section\_area = 30.00$

$f_y E = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 625.00$

$f_y E = (f_{y,ext\_Trans\_Reinf} \cdot Area_{ext\_Trans\_Reinf} + f_{y,int\_Trans\_Reinf} \cdot Area_{int\_Trans\_Reinf}) / Area_{Tot\_Trans\_Rein} =$

625.00

$pl = \text{Area\_Tot\_Long\_Rein}/(b*d) = 0.01461445$

$b = 450.00$

$d = 407.00$

$f_{cE} = 30.00$

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

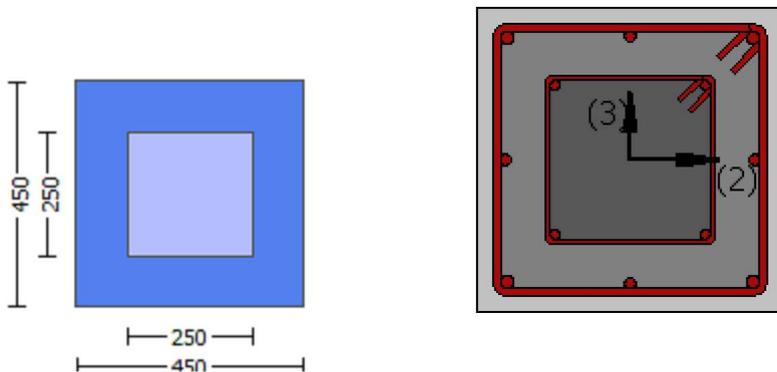
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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:  $A_{sl} = 0.00$

-Compression:  $A_{slc} = 2676.637$

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  $V_R = 1.0 * V_n = 464717.587$

$V_n$  ((10.3), ASCE 41-17) =  $knI * V_{CoI} = 464717.587$

$V_{CoI} = 464717.587$

$knI = 1.00$

displacement\_ductility\_demand = 0.00

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

-----  
= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 20.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 1.4066927E-009$

$V_u = 5.1543165E-013$   
 $d = 0.8 \cdot h = 360.00$   
 $N_u = 7504.363$   
 $A_g = 202500.00$   
 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:  $V_s + V_f \leq 481278.84$   
 $b_w = 450.00$

displacement ductility demand is calculated as  $\delta / y$

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

From analysis, chord rotation  $\theta = 1.4135252E-020$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00226492$  ((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  $\delta / y$  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)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/d)^{2/3}) = 253.6734$   
 $d = 407.00$   
 $y = 0.261003$   
 $A = 0.01477597$   
 $B = 0.00824076$   
 with  $pt = 0.00620943$   
 $pc = 0.00620943$   
 $pv = 0.0021956$   
 $N = 7504.363$   
 $b = 450.00$   
 $\theta = 0.10565111$   
 $y_{comp} = 1.9895862E-005$   
 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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

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

At local axis: 3

Integration Section: (a)

## Calculation No. 4

column C1, Floor 1

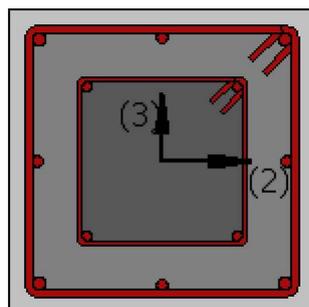
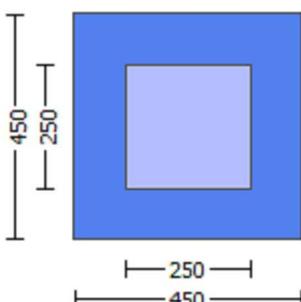
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

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:  $A_{sl,t} = 0.00$

-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

$M_{u1-} = 1.3261E+008$ , 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

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

$M_{u2+} = 1.3261E+008$ , 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

$M_{u2-} = 1.3261E+008$ , 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  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.9430876E-006$

$M_u = 1.3261E+008$   
-----

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

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)

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

$w_e$  (5.4c) = 0.02630475

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

$a_{se1} = 0.2533421$

$b_{o1} = 390.00$

$h_{o1} = 390.00$

$b_{i2,1} = 608400.00$

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

$b_{o2} = 242.00$

$h_{o2} = 242.00$

$b_{i2,2} = 234256.00$

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

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

$p_{s1}$  (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,  $n_{s,2} = 2.00$

$h_2 = 250.00$   
-----

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

$p_{s1}$  (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,  $n_{s,2} = 2.00$

$h_2 = 250.00$   
-----

$A_{sec} = 202500.00$

$s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 781.25$   
 $fy_{we2} = 781.25$   
 $f_{ce} = 30.00$   
 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.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$   
 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  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal \text{ ((5.5), TBDY)} = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 273.2614$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / f_c) = 0.05655989$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / f_c) = 0.05655989$   
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 32.82751$   
 $cc \text{ (5A.5, TBDY)} = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / f_c) = 0.07045463$

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

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

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  $l_b/l_d$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

-----  
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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0099875$

$$w_e(5.4c) = 0.02630475$$

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

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

$$h_{o_1} = 390.00$$

$$b_{i2_1} = 608400.00$$

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

$$b_{o_2} = 242.00$$

$$h_{o_2} = 242.00$$

$$b_{i2_2} = 234256.00$$

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

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  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , 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  $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$ , 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

$l_b/l_{d,min} = l_b/l_d = 0.14801896$

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

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

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

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

$\gamma_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 273.2614$

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

$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05655989$

$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05655989$

$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

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

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

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

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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$ , 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  $M_{u2+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 8.9430876E-006$

$M_u = 1.3261E+008$

-----  
with full section properties:

$b = 450.00$

$d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $fc = 30.00$   
 $co (5A.5, TBDY) = 0.002$   
 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:  $cu = 0.0099875$   
 $w_e (5.4c) = 0.02630475$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.2533421$   
 $ase1 = 0.2533421$   
 $bo_1 = 390.00$   
 $ho_1 = 390.00$   
 $bi2_1 = 608400.00$   
 $ase2 = Max(ase1, ase2) = 0.2533421$   
 $bo_2 = 242.00$   
 $ho_2 = 242.00$   
 $bi2_2 = 234256.00$   
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No 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,  $ns_2 = 2.00$   
 $h2 = 250.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00349066$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No 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  
 $Shear\_factor = 1.00$

$lo/lo_{u,min} = lb/d = 0.14801896$   
 $su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

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

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  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , 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

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

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

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.

$$\text{with } fsv = (fs\_jacket*Asl,mid,jacket + fs\_mid*Asl,mid,core)/Asl,mid = 273.2614$$

$$\text{with } Esv = (Es\_jacket*Asl,mid,jacket + Es\_mid*Asl,mid,core)/Asl,mid = 200000.00$$

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

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

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908$$

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)

---->

$v < vs,y2$  - 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  $fc'^{0.5} \leq 8.3$   
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  $\phi_u$  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  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.0099875$   
we (5.4c) = 0.02630475  
ase ((5.4d), TBDY) =  $(\text{ase1} * \text{Aext} + \text{ase2} * \text{Aint}) / \text{Asec} = 0.2533421$   
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) =  $(\text{Ash1} * \text{h1} / \text{s1}) / \text{Asec} = 0.00349066$   
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 450.00  
ps2 (internal) =  $(\text{Ash2} * \text{h2} / \text{s2}) / \text{Asec} = 0.00049645$   
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) =  $(\text{Ash1} * \text{h1} / \text{s1}) / \text{Asec} = 0.00349066$   
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 450.00  
ps2 (internal) =  $(\text{Ash2} * \text{h2} / \text{s2}) / \text{Asec} = 0.00049645$   
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

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 273.2614$$

$$\text{with } Es_1 = (Es_{\text{jacket}} * Asl, \text{ten, jacket} + Es_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y_2 = 0.00087444$$

$$sh_2 = 0.0027982$$

$$ft_2 = 327.9137$$

$$fy_2 = 273.2614$$

$$su_2 = 0.0027982$$

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

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

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

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

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

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

$$\text{with } fs_2 = (fs_{\text{jacket}} * Asl, \text{com, jacket} + fs_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 273.2614$$

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

$$y_v = 0.00087444$$

$$sh_v = 0.0027982$$

$$ft_v = 327.9137$$

$$fy_v = 273.2614$$

$$suv = 0.0027982$$

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

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

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

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

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv_{\text{nominal}}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered

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

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

$$\text{with } fsv = (fs_{\text{jacket}} * Asl, \text{mid, jacket} + fs_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 273.2614$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.05655989$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.05655989$$

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

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 32.82751$$

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

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.07045463$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.07045463$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.02491213$$

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/l<sub>d</sub>

-----  
Lap Length: lb/l<sub>d</sub> = 0.14801896

lb = 300.00

l<sub>d</sub> = 2026.767

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

l<sub>d,min</sub> 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<sub>y</sub> = 781.25

Mean concrete strength: f<sub>c</sub>' = (f<sub>c</sub>'<sub>jacket</sub>\*Area<sub>jacket</sub> + f<sub>c</sub>'<sub>core</sub>\*Area<sub>core</sub>)/Area<sub>section</sub> = 30.00, but f<sub>c</sub>'<sup>0.5</sup> <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 3.43481

A<sub>tr</sub> = Min(A<sub>tr\_x</sub>,A<sub>tr\_y</sub>) = 257.6106

where A<sub>tr\_x</sub>, A<sub>tr\_y</sub> are the sum of the area of all stirrup legs along X and Y loxal axis

s = Max(s<sub>external</sub>,s<sub>internal</sub>) = 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: f<sub>c</sub>' = (f<sub>c</sub>'<sub>jacket</sub>\*Area<sub>jacket</sub> + f<sub>c</sub>'<sub>core</sub>\*Area<sub>core</sub>)/Area<sub>section</sub> = 30.00, but f<sub>c</sub>'<sup>0.5</sup> <= 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:  $A_{st} = 0.00$   
   -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:  $A_{sc,mid} = 402.1239$   
 -----  
 -----  
 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  $\mu_{u1+}$   
 -----  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$$w_e(5.4c) = 0.02630475$$

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{o, \min} = l_b / d = 0.14801896$$

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

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

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

characteristic value  $f_{sy1} = f_{s1}/1.2$ , 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  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 273.2614$

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

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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

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

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

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  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , 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  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.00087444$

$sh_v = 0.0027982$

$ft_v = 327.9137$

$fy_v = 273.2614$

$su_v = 0.0027982$

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

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

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

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

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

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

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

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , 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:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

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

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

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

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:  $f_y = 781.25$   
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 local axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 12.00$

-----  
-----  
-----  
Calculation of  $\mu_{u1}$ -  
-----

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

with full section properties:

$b = 450.00$   
 $d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $f_c = 30.00$   
 $\alpha$  (5A.5, TBDY) = 0.002  
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0099875$   
 $w_e$  (5.4c) = 0.02630475  
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$   
 $a_{se1} = 0.2533421$   
 $b_{o1} = 390.00$   
 $h_{o1} = 390.00$   
 $b_{i2_1} = 608400.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$   
 $b_{o2} = 242.00$   
 $h_{o2} = 242.00$   
 $b_{i2_2} = 234256.00$   
 $p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.11493$

-----  
 $p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.11493$   
 $p_{s1}$  (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,  $n_{s_2} = 2.00$   
 $h_2 = 250.00$   
-----

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,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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.  
with fs1 = (fsjacket\*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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/l<sub>d</sub>

Lap Length: lb/l<sub>d</sub> = 0.14801896

lb = 300.00

l<sub>d</sub> = 2026.767

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

l<sub>d,min</sub> 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 local 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\*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

$$psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 3.11493$$

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

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

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 450.00$$

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

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 250.00$$

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

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

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 450.00$$

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

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

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

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

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

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

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

$$l_0/l_{ou,min} = l_b/l_d = 0.14801896$$

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

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

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

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

$$\gamma_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05655989$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05655989$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 32.82751$$

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

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

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

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

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

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)

$$= 1$$

$$d_b = 16.66667$$

$$\text{Mean strength value of all re-bars: } f_y = 781.25$$

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

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

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

$$n = 12.00$$

-----  
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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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

$$su_1 = 0.4 * e_{su1\_nominal} \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{su1\_nominal} = 0.08,$$

For calculation of  $e_{su1\_nominal}$  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.

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

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

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

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), 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 = 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  $fc'^{0.5} \leq 8.3$

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 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).

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

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

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  $\text{Col2} = 0.00$

$$s/d = 1.25$$

$V_f$  ((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,  $V_{r2} = 575966.892$   
-----

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

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

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

-----  
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).

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

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

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

Vu = 2.9582284E-031  
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: 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, = 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,  $M = -1.8336E+007$

Shear Force,  $V2 = -6110.425$

Shear Force,  $V3 = -5.1543165E-013$

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:  $As_{,ten} = 1137.257$

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

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

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

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

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

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

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

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

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

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = 1.0^*$   $u = 0.00453094$

$u = y + p = 0.00453094$

- Calculation of  $y$  -

$y = (My * Ls / 3) / Eleff = 0.00453094$  ((4.29), Biskinis Phd))

$My = 1.1955E+008$

$Ls = M/V$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 30.00$

$N = 7504.363$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 8.7969E+013$

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)  $fy = \text{Min}(fy, 1.25 * fy * (lb/d)^{2/3}) = 253.6734$

$d = 407.00$

$y = 0.261003$

$A = 0.01477597$

$B = 0.00824076$

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  $E_s = 200000.00$

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)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

- Calculation of  $\rho$  -

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

with:

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

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

$d = d_{external} = 407.00$

$s = s_{external} = 0.00$

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

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

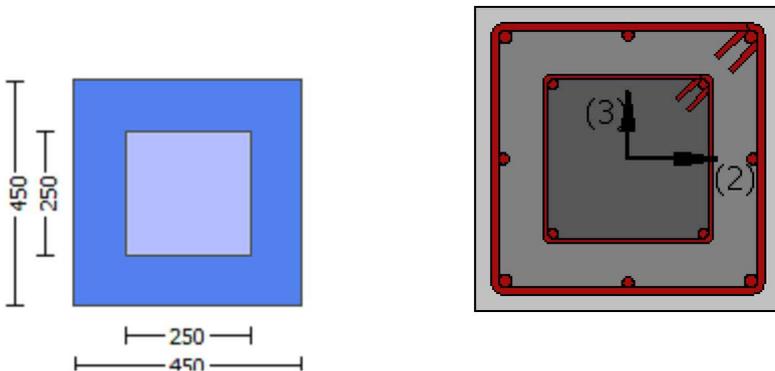
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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  $135^\circ$ )  
 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) =  $k_n \cdot V_{CoI} = 464717.587$   
 $V_{CoI} = 464717.587$   
 $k_n = 1.00$   
 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

$$b_w = 450.00$$

displacement ductility demand is calculated as  $\delta / y$

- Calculation of  $\delta / y$  for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 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  $\delta / y$  and  $M_y$  according to Annex 7 -

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

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

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

$$d = 407.00$$

$$y = 0.261003$$

$$A = 0.01477597$$

$$B = 0.00824076$$

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

$$p_c = 0.00620943$$

$$p_v = 0.0021956$$

$$N = 7504.363$$

$$b = 450.00$$

$$r = 0.10565111$$

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

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  $I_b / I_d$

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)

$$= 1$$

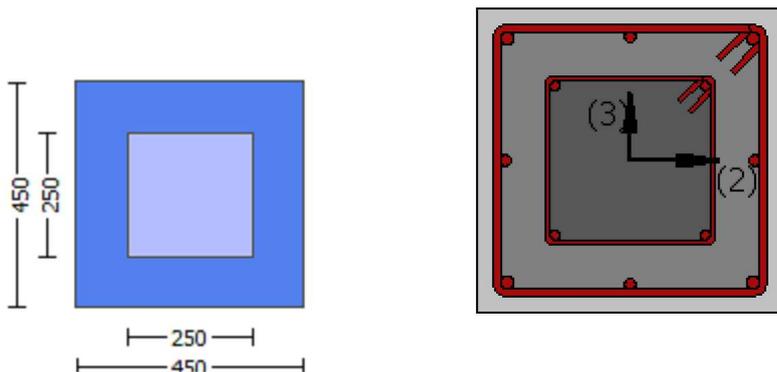
$$d_b = 16.66667$$

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 (  $\mu$  )  
 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,  $= 1.00$   
 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:  $A_{sl,t} = 0.00$   
 · -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  
 ·  $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3261E+008$   
 ·  $Mu_{1+} = 1.3261E+008$ , 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 Mu1+  
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

-----

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

-----

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

-----

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

-----

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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 Min(1,1.25\*(lb/d)^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/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\*(lb/d)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 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/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 local axis

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

$n = 12.00$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_1 = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

$\phi_0$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u = \text{shear\_factor} \cdot \max(\phi_u, \phi_c) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$\omega_e$  (5.4c) = 0.02630475

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

$\omega_{ase1} = 0.2533421$

$\omega_{bo_1} = 390.00$

$\omega_{ho_1} = 390.00$

$\omega_{bi2_1} = 608400.00$

$\omega_{ase2} = \max(\omega_{ase1}, \omega_{ase2}) = 0.2533421$

$\omega_{bo_2} = 242.00$

$\omega_{ho_2} = 242.00$

$\omega_{bi2_2} = 234256.00$

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

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

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

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

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 450.00$

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

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

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 250.00$

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

$\phi_{sh1}$  (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,  $ns_1 = 2.00$   
 $h1 = 450.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00049645$   
 $Ash2 = Astir\_2 \cdot ns_2 = 100.531$   
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

$lo/lou,min = lb/ld = 0.14801896$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

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

$lo/lou,min = lb/lb,min = 0.14801896$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((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

$lo/lou,min = lb/ld = 0.14801896$   
 $suv = 0.4 \cdot esuv\_nominal$  ((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  $Esv = (Es,jacket \cdot Asl,mid,jacket + Es,mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.05655989$   
 $2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.05655989$   
 $v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 32.82751$$

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

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

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

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

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

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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

-----  
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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

ho\_1 = 390.00  
bi2\_1 = 608400.00  
ase2 = 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,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  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00087444$   
 $sh_v = 0.0027982$   
 $ft_v = 327.9137$   
 $fy_v = 273.2614$   
 $su_v = 0.0027982$   
 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  
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 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:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 32.82751$   
 $cc(5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

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

-----  
 -----  
 -----

#### Calculation of $Mu_2$

-----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

$$\text{ase ((5.4d), TBDY) = } (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.2533421$$

$$\text{ase}_1 = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.2533421$$

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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

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

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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  $Esv = (Es\_jacket \cdot Asl,mid,jacket + Es\_mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

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

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

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

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 32.82751$$

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

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

$$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07045463$$

$$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.07045463$$

$$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su \text{ (4.9)} = 0.23123015$$

$$Mu = MRc \text{ (4.14)} = 1.3261E+008$$

$$u = su \text{ (4.1)} = 8.9430876E-006$$

Calculation of ratio  $lb/ld$

$$\text{Lap Length: } lb/ld = 0.14801896$$

$$lb = 300.00$$

$$ld = 2026.767$$

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 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,  $V_{r1} = 575966.892$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$$V_{\text{Col}0} = 575966.892$$

$k_{nl} = 1$  (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)

$$M/Vd = 2.00$$

$$\mu_u = 8.8568787E-012$$

$$\nu_u = 1.2249986E-030$$

$$d = 0.8 \cdot h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

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  $\text{Col}1 = 1.00$

$$s/d = 0.27777778$$

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

$$d = 200.00$$

$$A_v = 100530.965$$

$$f_y = 625.00$$

$$s = 250.00$$

$V_{s2}$  is multiplied by  $\text{Col}2 = 0.00$

$$s/d = 1.25$$

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

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

$$b_w = 450.00$$

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

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$$V_{\text{Col}0} = 575966.892$$

$k_{nl} = 1$  (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)  
 $M/Vd = 2.00$   
 $\mu_u = 8.8568787E-012$   
 $V_u = 1.2249986E-030$   
 $d = 0.8 \cdot h = 360.00$   
 $N_u = 7506.808$   
 $A_g = 202500.00$   
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:  $V_s + V_f \leq 589443.792$   
 $b_w = 450.00$

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:  $A_{st}$  = 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:  $A_{st,mid}$  = 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  
 $M_{u1-} = 1.3261E+008$ , 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  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3261E+008$   
 $M_{u2+} = 1.3261E+008$ , 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  
 $M_{u2-} = 1.3261E+008$ , 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  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  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<sub>c</sub> = 30.00  
c<sub>o</sub> (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$

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) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o\_1} = 390.00$

$h_{o\_1} = 390.00$

$b_{i2\_1} = 608400.00$

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

$b_{o\_2} = 242.00$

$h_{o\_2} = 242.00$

$b_{i2\_2} = 234256.00$

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

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

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

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

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

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

$c$  = 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

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

$su_1 = 0.4 * e_{su1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1\_nominal} = 0.08$ ,

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_s / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, 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  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 273.2614$   
 with  $Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00087444$   
 $shv = 0.0027982$   
 $ftv = 327.9137$   
 $fyv = 273.2614$   
 $suv = 0.0027982$   
 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  
 $lo/lo_{u,min} = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 273.2614$   
 with  $Es_v = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.05655989$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.05655989$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07045463$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07045463$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - 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  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$\phi_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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  $l_b/d$

Lap Length:  $l_b/d = 0.14801896$

$l_b = 300.00$

$d = 2026.767$

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

$l_b, \min$  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 local axis

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

$n = 12.00$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.0099875$

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) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i2_1} = 608400.00$

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

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i2_2} = 234256.00$

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

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

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

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

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 450.00$

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

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

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 250.00$

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

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

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 450.00$$

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

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.14801896$$

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

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

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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.

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

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

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

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

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05655989$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.01999908$$

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  $l_b/d$

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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$$w_e (5.4c) = 0.02630475$$

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

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

with  $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 273.2614$

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

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

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

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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , 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

$c$  = 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  $lb/d$

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:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 30.00$ , 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,  $V_{r1} = 575966.892$

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

$V_{Col0} = 575966.892$

$knl = 1$  (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)

$M / Vd = 2.00$

$\mu_u = 2.0434592E-012$

$V_u = 2.9582284E-031$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

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:  $V_s + V_f \leq 589443.792$

$bw = 450.00$   
-----

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)

$M / Vd = 2.00$

$\mu_u = 2.0434592E-012$

$V_u = 2.9582284E-031$

$d = 0.8 * h = 360.00$

$N_u = 7506.808$

$A_g = 202500.00$

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: Asc = 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)  $fy = \text{Min}(fy, 1.25*fy*((lb/d)^{2/3}) = 253.6734$

$d = 407.00$

$y = 0.261003$

$A = 0.01477597$

$B = 0.00824076$

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  $lb/d$

Lap Length:  $ld/d,min = 0.1850237$

$lb = 300.00$

$ld = 1621.414$

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  $\rho$  -  
 -----

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

with:

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

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

$d = d_{\text{external}} = 407.00$

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

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_f e / f_s) = 0.00398711$

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  $2 \cdot t_f / b_w \cdot (f_f e / f_s)$  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  $f_f e / f_s$  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.

$N_{UD} = 7504.363$

$A_g = 202500.00$

$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 30.00$

$f_{yIE} = (f_{y_{\text{ext\_Long\_Reinf}}} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 625.00$

$f_{yTE} = (f_{y_{\text{ext\_Trans\_Reinf}}} \cdot \text{Area}_{\text{ext\_Trans\_Reinf}} + f_{y_{\text{int\_Trans\_Reinf}}} \cdot \text{Area}_{\text{int\_Trans\_Reinf}}) / \text{Area}_{\text{Tot\_Trans\_Rein}} = 625.00$

$\rho_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01461445$

$b = 450.00$

$d = 407.00$

$f_{cE} = 30.00$

-----  
 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

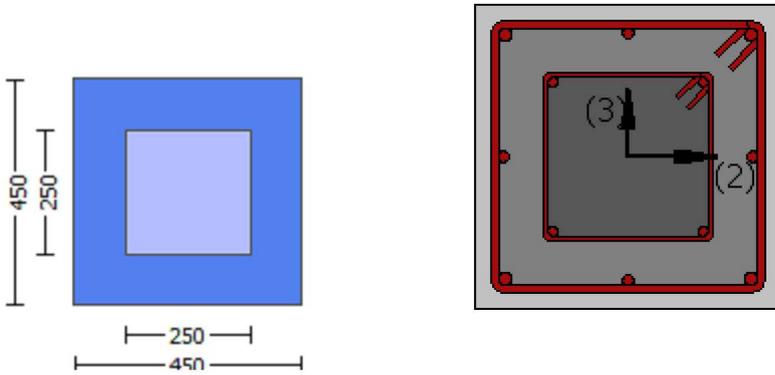
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{s,ten} = 1137.257$   
-Compression:  $A_{s,com} = 1137.257$   
-Middle:  $A_{s,mid} = 402.1239$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$

-----  
New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 * V_n = 464717.587$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI} = 464717.587$   
 $V_{CoI} = 464717.587$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.00

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

-----  
= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 20.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa ((22.5.3.1, ACI 318-14)  
 $M / V_d = 2.00$   
 $M_u = 1.3991829E-010$   
 $V_u = 5.1543165E-013$   
 $d = 0.8 * h = 360.00$   
 $N_u = 7504.363$   
 $A_g = 202500.00$   
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  $\phi / y$

- Calculation of  $\phi / y$  for END B -  
for rotation axis 2 and integ. section (b)

From analysis, chord rotation  $\theta = 6.3379047E-021$

$y = (M_y * L_s / 3) / E_{eff} = 0.00226492$  ((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  $\phi$  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  $p_t = 0.00620943$

$p_c = 0.00620943$

$p_v = 0.0021956$

$N = 7504.363$

$b = 450.00$

" = 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:  $l_d / l_d, \text{min} = 0.1850237$

$l_b = 300.00$

$l_d = 1621.414$

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

$l_d, \text{min}$  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:  $f'_c = (f'_{c\_jacket} * Area_{jacket} + f'_{c\_core} * Area_{core}) / Area_{section} = 30.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

$A_{tr} = \text{Min}(A_{tr\_x}, A_{tr\_y}) = 257.6106$

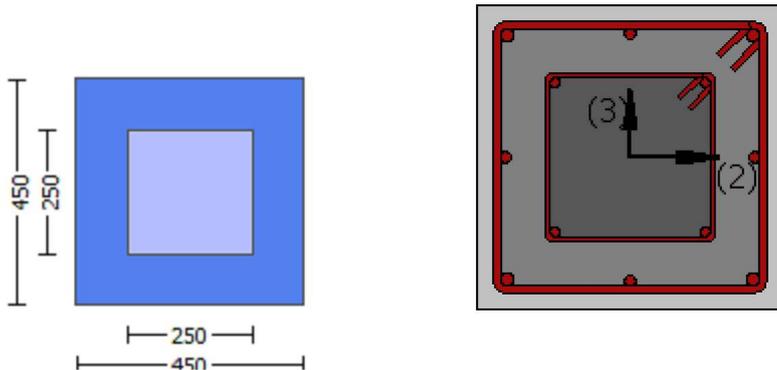
where  $A_{tr\_x}$ ,  $A_{tr\_y}$  are the sum of the area of all stirrup legs along X and Y local axis

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

End Of Calculation of Shear Capacity for element: column JC1 of floor 1  
 At local axis: 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:  $A_{st} = 0.00$

-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:  $A_{st,mid} = 402.1239$

-----  
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

$M_{u1-} = 1.3261E+008$ , 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

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

$M_{u2+} = 1.3261E+008$ , 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

$M_{u2-} = 1.3261E+008$ , 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  $M_{u1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.9430876E-006$

$M_u = 1.3261E+008$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$$w_e (5.4c) = 0.02630475$$

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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

$$su_1 = 0.4 * e_{su1\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{su1\_nominal} = 0.08,$$

For calculation of  $e_{su1\_nominal}$  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.

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

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

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

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), 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 = 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  $fc'^{0.5} \leq 8.3$

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  $\mu_1$ -  
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$\mu = 1.3261E+008$$

-----  
with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$$\mu_{cc} \text{ (5.4c)} = 0.02630475$$

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

fywe1 = 781.25  
fywe2 = 781.25  
fce = 30.00

From ((5.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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/l<sub>d</sub>

-----  
Lap Length: lb/l<sub>d</sub> = 0.14801896

lb = 300.00

l<sub>d</sub> = 2026.767

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

l<sub>d,min</sub> 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<sub>tr</sub> = 3.43481

A<sub>tr</sub> = Min(A<sub>tr\_x</sub>, A<sub>tr\_y</sub>) = 257.6106

where A<sub>tr\_x</sub>, A<sub>tr\_y</sub> are the sum of the area of all stirrup legs along X and Y local axis

s = Max(s<sub>external</sub>, s<sub>internal</sub>) = 250.00

n = 12.00

-----  
Calculation of Mu<sub>2+</sub>

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

$$\text{with } fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 273.2614$$

$$\text{with } Esv = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$$

$$1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.05655989$$

$$2 = Asl\_com / (b * d) * (fs2 / fc) = 0.05655989$$

$$v = Asl\_mid / (b * d) * (fsv / fc) = 0.01999908$$

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)

--->

$v < vs,y2$  - 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  $fc'^{0.5} \leq 8.3$  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 local axis

$$s = \text{Max}(s\_external, s\_internal) = 250.00$$

$$n = 12.00$$

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.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  
 $Shear\_factor = 1.00$

$lo/lo_{u, min} = lb/ld = 0.14801896$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$

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

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

$$su_2 = 0.0027982$$

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

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

$$su_2 = 0.4 * esu_2,nominal ((5.5), TBDY) = 0.032$$

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

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 273.2614$$

$$\text{with } Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 273.2614$$

$$\text{with } Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.05655989$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.05655989$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.01999908$$

and confined core properties:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

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

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

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

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.07045463$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.07045463$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.02491213$$

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 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 local 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,  $V_{r1} = 575966.892$

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

$V_{Col0} = 575966.892$

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  $Col2 = 0.00$

$s/d = 1.25$

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

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

$b_w = 450.00$

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

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

$V_{Col0} = 575966.892$

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  $Col2 = 0.00$

$s/d = 1.25$

$V_f$  ((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,  $f_s = 1.25 * f_{sm} = 781.25$

Existing Column

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

#####

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:  $As_{c,com} = 1137.257$   
-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 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  $\mu_{u1+}$   
-----

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

with full section properties:

$b = 450.00$   
 $d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $f_c = 30.00$   
 $\alpha_1$  (5A.5, TBDY) = 0.002  
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0099875$   
 $\mu_w$  (5.4c) = 0.02630475  
 $\mu_{ase}$  ((5.4d), TBDY) =  $(\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.2533421$   
 $\mu_{ase1} = 0.2533421$   
 $\mu_{bo_1} = 390.00$   
 $\mu_{ho_1} = 390.00$   
 $\mu_{bi2_1} = 608400.00$   
 $\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.2533421$   
 $\mu_{bo_2} = 242.00$

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 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

$f_{yv} = 273.2614$   
 $s_{uv} = 0.0027982$   
 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  
 $l_o/l_{ou,min} = l_b/l_d = 0.14801896$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $e_{suv\_nominal} = 0.08$ ,  
 considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $e_{suv\_nominal}$  and  $\gamma_v$ ,  $sh_v$ ,  $ft_v$ ,  $f_{yv}$ , it is considered  
 characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $\gamma_1$ ,  $sh_1$ ,  $ft_1$ ,  $f_{y1}$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 with  $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.05655989$   
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.05655989$   
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.01999908$

and confined core properties:

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

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

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

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

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

-----  
 Calculation of  $Mu_1$ -  
 -----

-----  
 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:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.0099875$

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

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$

ps1 (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00349066$

Ash1 =  $A_{stir\_1} * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

h1 = 450.00

ps2 (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00049645$

Ash2 =  $A_{stir\_2} * ns_2 = 100.531$

No stirups,  $ns_2 = 2.00$

h2 = 250.00

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.11493$

ps1 (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00349066$

Ash1 =  $A_{stir\_1} * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

h1 = 450.00

ps2 (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00049645$

Ash2 =  $A_{stir\_2} * ns_2 = 100.531$

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 =  $lb/d = 0.14801896$

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

$$\text{with } fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 273.2614$$

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$
 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  

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

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

$$\text{with } fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 273.2614$$

$$\text{with } Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$$

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$
 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  

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

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$$
 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.  

$$\text{with } fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$$

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

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

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

$$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$$
 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  $lb,min$  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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$ , 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 local axis

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

$$n = 12.00$$

-----  
-----  
-----  
Calculation of  $\mu_{2+}$   
-----

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$\mu_u = 1.3261E+008$$

-----  
with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o1} = 390.00$$

$$h_{o1} = 390.00$$

$$b_{i2,1} = 608400.00$$

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

$$b_{o2} = 242.00$$

$$h_{o2} = 242.00$$

$$b_{i2,2} = 234256.00$$

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

$$p_{sh_x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$$

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

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

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

$$h_1 = 450.00$$

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

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

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

$$h_2 = 250.00$$

$$p_{sh_y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 3.11493$$

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

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

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

$$h_1 = 450.00$$

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

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

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

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 781.25$   
 $fy_{we2} = 781.25$   
 $f_{ce} = 30.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $y_1 = 0.00087444$   
 $sh_1 = 0.0027982$   
 $ft_1 = 327.9137$   
 $fy_1 = 273.2614$   
 $su_1 = 0.0027982$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 0.14801896$   
 $su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, ten, jacket + fs_{core} * Asl, ten, core) / Asl, ten = 273.2614$   
 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  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 0.14801896$   
 $su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl, com, jacket + fs_{core} * Asl, com, core) / Asl, com = 273.2614$   
 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  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl, mid, jacket + fs_{mid} * Asl, mid, core) / Asl, mid = 273.2614$   
 with  $Es_v = (Es_{jacket} * Asl, mid, jacket + Es_{mid} * Asl, mid, core) / Asl, mid = 200000.00$   
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.05655989$   
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.05655989$   
 $v = Asl, mid / (b * d) * (fsv / f_c) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.07045463$

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

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

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

-----  
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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0099875$

$$w_e(5.4c) = 0.02630475$$

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

$$a_{se1} = 0.2533421$$

$$b_{o,1} = 390.00$$

$$h_{o,1} = 390.00$$

$$b_{i2,1} = 608400.00$$

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

$$b_{o,2} = 242.00$$

$$h_{o,2} = 242.00$$

$$b_{i2,2} = 234256.00$$

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

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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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 = (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  $fc'^{0.5} \leq 8.3$  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 =  $\text{Max}(s_{\text{external}}, s_{\text{internal}})$  = 250.00

n = 12.00

-----  
Calculation of Shear Strength Vr =  $\text{Min}(Vr1, Vr2)$  = 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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0434592E-012$   
 $\nu_u = 2.9582284E-031$   
 $d = 0.8 \cdot h = 360.00$   
 $N_u = 7506.808$   
 $A_g = 202500.00$   
 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  $\text{Col1} = 1.00$   
 $s/d = 0.27777778$   
 $V_{s2} = 0.00$  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), 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,  $V_{r2} = 575966.892$   
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$   
 $V_{\text{Col}0} = 575966.892$   
 $k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s1} + f \cdot V_f$ '  
 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)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0434592E-012$   
 $\nu_u = 2.9582284E-031$   
 $d = 0.8 \cdot h = 360.00$   
 $N_u = 7506.808$   
 $A_g = 202500.00$   
 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  $\text{Col1} = 1.00$   
 $s/d = 0.27777778$   
 $V_{s2} = 0.00$  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), 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:  $A_{sl} = 0.00$   
-Compression:  $A_{sc} = 2676.637$   
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,  $DbL = 16.80$   
-----

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^* u = 0.00045298$   
 $u = y + p = 0.00045298$

- Calculation of  $y$  -

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

$M_y = 1.1955E+008$

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

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 2.6391E+013$

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)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 253.6734$

$d = 407.00$

$y = 0.261003$

$A = 0.01477597$

$B = 0.00824076$

with  $p_t = 0.00398711$

$p_c = 0.00620943$

$p_v = 0.0021956$

$N = 7504.363$

$b = 450.00$

" = 0.10565111

$y_{comp} = 1.9895862E-005$

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  $I_b / I_d$

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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 30.00$ , 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 local axis

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

$$n = 12.00$$

-----  
 - Calculation of  $\rho$  -  
 -----

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

with:

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

$$\text{shear control ratio } V_y E / V_{CoI} E = 0.1534981$$

$$d = d_{\text{external}} = 407.00$$

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

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

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

$A_{v1} = 157.0796$ , 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.

$$N_{UD} = 7504.363$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 30.00$$

$$f_{yE} = (f_{y_{\text{ext\_Long\_Reinf}}} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 625.00$$

$$f_{yE} = (f_{y_{\text{ext\_Trans\_Reinf}}} \cdot \text{Area}_{\text{ext\_Trans\_Reinf}} + f_{y_{\text{int\_Trans\_Reinf}}} \cdot \text{Area}_{\text{int\_Trans\_Reinf}}) / \text{Area}_{\text{Tot\_Trans\_Rein}} = 625.00$$

$$\rho_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

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

At local axis: 3

Integration Section: (b)  
 -----

## Calculation No. 9

column C1, Floor 1

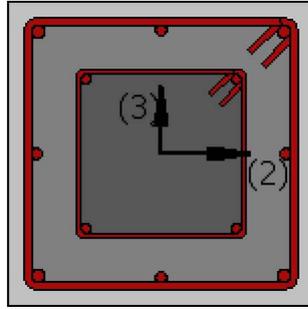
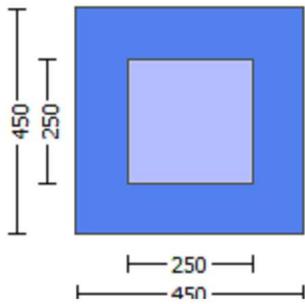
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$   
N = 7502.943  
 $E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 8.7969E+013$

-----  
Calculation of Yielding Moment My

-----  
Calculation of  $y$  and My according to Annex 7 -

-----  
y = Min(  $y_{\text{ten}}$ ,  $y_{\text{com}}$  )  
 $y_{\text{ten}} = 4.2170387E-006$   
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  
 $y_{\text{comp}} = 1.9895870E-005$   
with  $f_c = 30.00$   
Ec = 25742.96  
y = 0.25904663  
A = 0.01451681  
B = 0.00807924  
with Es = 200000.00

-----  
Calculation of ratio  $l_b/d$

-----  
Lap Length:  $l_d/l_{d,\text{min}} = 0.1850237$   
 $l_b = 300.00$   
 $l_d = 1621.414$   
Calculation of  $l$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $l_{d,\text{min}}$  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  
Ktr = 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( $s_{\text{external}}$ ,  $s_{\text{internal}}$ ) = 250.00  
n = 12.00

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

At local axis: 2

Integration Section: (a)

## Calculation No. 10

column C1, Floor 1

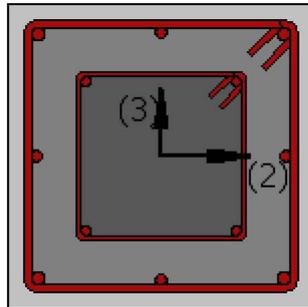
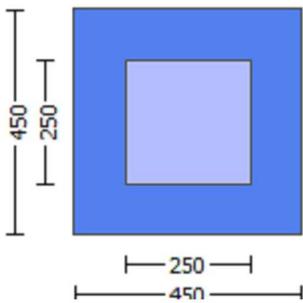
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

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  $135^\circ$ )  
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  $\mu_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu_u$  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  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.0099875$   
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\*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/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 = (fsjacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 273.2614

with Es1 = (Esjacket\*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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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  $Shear\_factor = 1.00$

$lo/lo_{u,min} = lb/ld = 0.14801896$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.032$

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

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

$y_1$ ,  $sh_{1,ft1,fy1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

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

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

-----  
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:  $f_y = 781.25$

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 local axis

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

$n = 12.00$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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 = 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/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  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of  $\phi_c$ :  $\phi_c^* = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$\omega_e$  (5.4c) = 0.02630475

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

$\omega_{ase1} = 0.2533421$

$\omega_{bo_1} = 390.00$

$\omega_{ho_1} = 390.00$

$\omega_{bi2_1} = 608400.00$

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

$\omega_{bo_2} = 242.00$

$\omega_{ho_2} = 242.00$

$\omega_{bi2_2} = 234256.00$

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

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

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

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

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 450.00$

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

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

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 250.00$

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

$\phi_{sh1}$  (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,  $ns_1 = 2.00$   
 $h1 = 450.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00049645$   
 $Ash2 = Astir\_2 \cdot ns_2 = 100.531$   
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:  $cc = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$

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

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

$lo/lou, \min = lb/ld = 0.14801896$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((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  
Shear\_factor = 1.00

$lo/lou, \min = lb/lb, \min = 0.14801896$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y2, sh2, ft2, fy2$ , 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  
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  $fsv = (fs\_jacket \cdot Asl, \text{mid}, \text{jacket} + fs\_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 273.2614$

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  $l_b/l_d$

$$\text{Lap Length: } l_b/l_d = 0.14801896$$

$$l_b = 300.00$$

$$l_d = 2026.767$$

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 local axis

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

$$n = 12.00$$

Calculation of  $M_u$

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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

ho\_1 = 390.00  
bi2\_1 = 608400.00  
ase2 = 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,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  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00087444$   
 $sh_v = 0.0027982$   
 $ft_v = 327.9137$   
 $fy_v = 273.2614$   
 $su_v = 0.0027982$   
 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  
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$   
 $su_v = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 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:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

#### 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 local 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,  $V_{r1} = 575966.892$

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

$V_{ColO} = 575966.892$

$kn1 = 1$  (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  $Col2 = 0.00$

$s/d = 1.25$

$V_f$  ((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,  $V_{r2} = 575966.892$

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

$V_{ColO} = 575966.892$

$kn1 = 1$  (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 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  $\phi_u$  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, TBDY) = 0.002

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)

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

$w_e$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.11493$

$psh_x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = Astir_1 * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = Astir_2 * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.11493  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00349066  
Ash<sub>1</sub> = Astir<sub>1</sub>\*ns<sub>1</sub> = 157.0796  
No stirups, ns<sub>1</sub> = 2.00  
h<sub>1</sub> = 450.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00049645  
Ash<sub>2</sub> = Astir<sub>2</sub>\*ns<sub>2</sub> = 100.531  
No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

Asec = 202500.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 781.25

fywe<sub>2</sub> = 781.25

fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y<sub>1</sub> = 0.00087444

sh<sub>1</sub> = 0.0027982

ft<sub>1</sub> = 327.9137

fy<sub>1</sub> = 273.2614

su<sub>1</sub> = 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/l<sub>d</sub> = 0.14801896

su<sub>1</sub> = 0.4\*esu<sub>1\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>1\_nominal</sub> = 0.08,

For calculation of esu<sub>1\_nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + fs<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 273.2614

with Es<sub>1</sub> = (Es<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + Es<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 200000.00

y<sub>2</sub> = 0.00087444

sh<sub>2</sub> = 0.0027982

ft<sub>2</sub> = 327.9137

fy<sub>2</sub> = 273.2614

su<sub>2</sub> = 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/l<sub>b,min</sub> = 0.14801896

su<sub>2</sub> = 0.4\*esu<sub>2\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>2\_nominal</sub> = 0.08,

For calculation of esu<sub>2\_nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TBDY.

y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + fs<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 273.2614

with Es<sub>2</sub> = (Es<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + Es<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 200000.00

y<sub>v</sub> = 0.00087444

sh<sub>v</sub> = 0.0027982

ft<sub>v</sub> = 327.9137

fy<sub>v</sub> = 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/l<sub>d</sub> = 0.14801896

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsy<sub>v</sub> = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv<sub>nominal</sub> and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsy<sub>v</sub> = 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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$

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

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

$c$  = confinement factor = 1.09425

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02491213$

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  $lb/ld$

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 local axis

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

$n = 12.00$

-----  
Calculation of  $Mu_1$ -

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0099875$

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) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o\_1} = 390.00$

$h_{o\_1} = 390.00$

$b_{i2\_1} = 608400.00$

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

$b_{o\_2} = 242.00$

$h_{o\_2} = 242.00$

$b_{i2\_2} = 234256.00$

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

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

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

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

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

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

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

$su_1 = 0.4 * e_{su1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1\_nominal} = 0.08$ ,

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_s / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, 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  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 273.2614$   
 with  $Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00087444$   
 $shv = 0.0027982$   
 $ftv = 327.9137$   
 $fyv = 273.2614$   
 $suv = 0.0027982$   
 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  
 $lo/lo_{u,min} = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 273.2614$   
 with  $Es_v = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.05655989$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.05655989$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07045463$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07045463$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - 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  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$\mu_{2+} = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \mu_{2+}: \mu_{2+}^* = \text{shear\_factor} * \text{Max}(\mu_{2+}, c_o) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{2+} = 0.0099875$$

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su1 = 0.0027982$$

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.

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

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

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

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

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

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.

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

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

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

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

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

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.

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

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

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

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

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908$$

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 < 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:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 30.00$ , 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  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_2 = 1.3261E+008$

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  $\mu_2$ :  $\mu_2^* = shear\_factor \cdot \max(\mu_2, co) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_2 = 0.0099875$

$\mu_2$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \max(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

$psh, \min \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(Ash_1 \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$Ash_1 = Astir_1 \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(Ash_2 \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$Ash_2 = Astir_2 \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h_2 = 250.00$

$psh_y \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

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

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 450.00$$

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

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.14801896$$

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

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

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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  $l_b/d$

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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

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

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

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

$$V_{Co10} = 575966.892$$

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

-----  
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 (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)

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

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

where:

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: 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)

$$M/Vd = 2.00$$

$$Mu = 2.0434592E-012$$

$$Vu = 2.9582284E-031$$

$$d = 0.8*h = 360.00$$

$$Nu = 7506.808$$

$$Ag = 202500.00$$

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

where:

Vs1 = 353429.174 is calculated for jacket, with:

$$d = 360.00$$

$$A_v = 157079.633$$

$$f_y = 625.00$$

$$s = 100.00$$

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,  $\gamma = 1.00$

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,  $M = 2.2188820E-009$

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:  $A_{sl} = 1137.257$

-Compression:  $A_{slc} = 1539.38$

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,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.03820662$

$u = \gamma + \rho = 0.03820662$

- Calculation of  $\gamma$  -

$\gamma = (My * Ls / 3) / E_{eff} = 0.00226492$  ((4.29), Biskinis Phd))

$My = 1.1954E+008$

$L_s = M/V$  (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  $\rho_y$  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 local axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 12.00$

-----  
 - Calculation of  $\rho_p$  -

-----  
 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  $V_y/E/V_{colOE} = 0.1534981$   
 $d = d_{external} = 407.00$

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

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

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

$A_{v1} = 157.0796$ , 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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 30.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 625.00$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 625.00$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

-----  
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

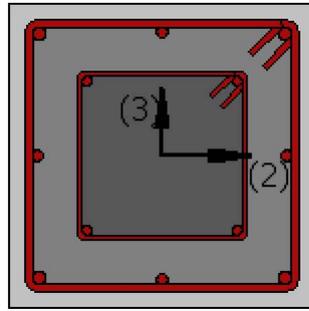
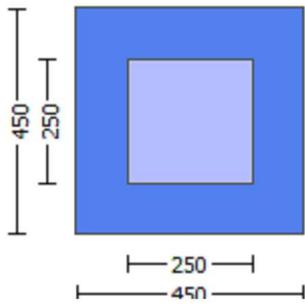
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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\*VColO = 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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$   
N = 7502.943  
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 8.7969E+013$

-----  
Calculation of Yielding Moment My

-----  
Calculation of  $y$  and My according to Annex 7 -

-----  
 $y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 4.2170387E-006$   
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  
 $y_{\text{comp}} = 1.9895870E-005$   
with  $f_c = 30.00$   
Ec = 25742.96  
y = 0.25904663  
A = 0.01451681  
B = 0.00807924  
with Es = 200000.00

-----  
Calculation of ratio  $l_b/d$

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

$l_b = 300.00$

$l_d = 1621.414$

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

$l_{d,\text{min}}$  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

Ktr = 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: 3

Integration Section: (a)

## Calculation No. 12

column C1, Floor 1

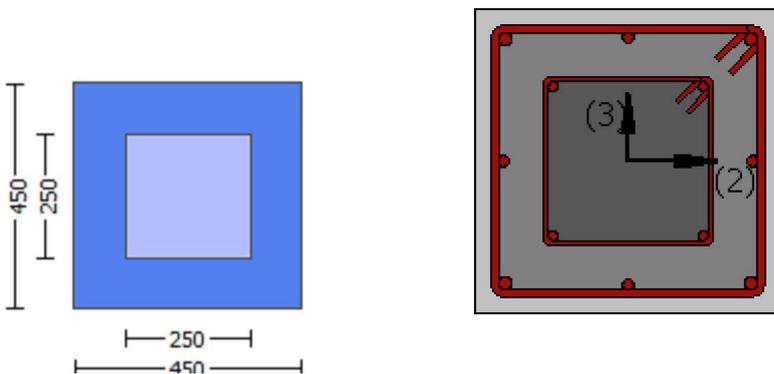
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

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  $135^\circ$ )  
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  $\mu_{u1+}$   
-----

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

-----  
with full section properties:

$b = 450.00$   
 $d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $f_c = 30.00$   
 $\alpha_1 (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0099875$

$w_e$  (5.4c) = 0.02630475  
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$   
 $a_{se1} = 0.2533421$   
 $b_{o\_1} = 390.00$   
 $h_{o\_1} = 390.00$   
 $b_{i2\_1} = 608400.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$   
 $b_{o\_2} = 242.00$   
 $h_{o\_2} = 242.00$   
 $b_{i2\_2} = 234256.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$   
 $A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$   
 No stirups,  $n_{s, 1} = 2.00$   
 $h_1 = 450.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$   
 $A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$   
 No stirups,  $n_{s, 2} = 2.00$   
 $h_2 = 250.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$   
 $A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$   
 No stirups,  $n_{s, 1} = 2.00$   
 $h_1 = 450.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$   
 $A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$   
 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.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  
 $\text{Shear\_factor} = 1.00$

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

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

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

For calculation of  $esu_{1, \text{nominal}}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fs_{y1} = fs_1 / 1.2$ , from table 5.1, TBDY.

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

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

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

$y_2 = 0.00087444$   
 $sh_2 = 0.0027982$   
 $ft_2 = 327.9137$   
 $fy_2 = 273.2614$   
 $su_2 = 0.0027982$

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

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

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

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

For calculation of  $es_{u2\_nominal}$  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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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

$lo/lo_{u,min} = lb/ld = 0.14801896$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5,5), TBDY) = 0.032$

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

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

$y_1$ ,  $sh_{1,ft1,fy1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

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

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

-----  
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:  $f_y = 781.25$

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 local axis

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

$n = 12.00$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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  $fs_1 = (f_s,jacket * A_{s,ten,jacket} + f_s,core * A_{s,ten,core}) / A_{s,ten} = 273.2614$

with  $Es_1 = (E_s,jacket * A_{s,ten,jacket} + E_s,core * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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  $fs_2 = (f_s,jacket * A_{s,com,jacket} + f_s,core * A_{s,com,core}) / A_{s,com} = 273.2614$

with  $Es_2 = (E_s,jacket * A_{s,com,jacket} + E_s,core * A_{s,com,core}) / A_{s,com} = 200000.00$

$y_v = 0.00087444$

$sh_v = 0.0027982$

$ft_v = 327.9137$

$fy_v = 273.2614$

$suv = 0.0027982$

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  $fsv = (f_s,jacket * A_{s,mid,jacket} + f_s,mid * A_{s,mid,core}) / A_{s,mid} = 273.2614$

with  $Esv = (E_s,jacket * A_{s,mid,jacket} + E_s,mid * A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.05655989$

$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.05655989$

$v = A_{s,mid} / (b * d) * (fsv / fc) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

$1 = A_{s,ten} / (b * d) * (fs_1 / fc) = 0.07045463$

$2 = A_{s,com} / (b * d) * (fs_2 / fc) = 0.07045463$

$v = A_{s,mid} / (b * d) * (fsv / fc) = 0.02491213$

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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$ , 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  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

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

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$\phi_w$  (5.4c) = 0.02630475

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

$\phi_{ase1} = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i_2_1} = 608400.00$

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

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i_2_2} = 234256.00$

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

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

$\phi_{psh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

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

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 450.00$

$\phi_{psh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

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

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 250.00$

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

$\phi_{psh1}$  (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,  $ns_1 = 2.00$   
 $h1 = 450.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00049645$   
 $Ash2 = Astir\_2 \cdot ns_2 = 100.531$   
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:  $cc = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$

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

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

$lo/lou, \min = lb/ld = 0.14801896$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((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  
Shear\_factor = 1.00

$lo/lou, \min = lb/lb, \min = 0.14801896$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y2, sh2, ft2, fy2$ , 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  
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  $fsv = (fs\_jacket \cdot Asl, \text{mid}, \text{jacket} + fs\_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 273.2614$

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  $l_b/d$

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)

$$= 1$$

$$d_b = 16.66667$$

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 local axis

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

$$n = 12.00$$

Calculation of  $M_u$

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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

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)

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 = 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/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  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00087444$   
 $sh_v = 0.0027982$   
 $ft_v = 327.9137$   
 $fy_v = 273.2614$   
 $su_v = 0.0027982$   
 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  
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 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:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 32.82751$   
 $cc(5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

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

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

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

$V_{Col0} = 575966.892$

$kn1 = 1$  (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  $Col2 = 0.00$

$s/d = 1.25$

$V_f$  ((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,  $V_{r2} = 575966.892$

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

$V_{Col0} = 575966.892$

$kn1 = 1$  (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:  $As_{,ten} = 1137.257$

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

-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 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  $\phi_u$  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, TBDY) = 0.002

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)

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

$w_e$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

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

$psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = Astir_1 * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = Astir_2 * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.11493  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00349066  
Ash<sub>1</sub> = Astir<sub>1</sub>\*ns<sub>1</sub> = 157.0796  
No stirups, ns<sub>1</sub> = 2.00  
h<sub>1</sub> = 450.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00049645  
Ash<sub>2</sub> = Astir<sub>2</sub>\*ns<sub>2</sub> = 100.531  
No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

Asec = 202500.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 781.25

fywe<sub>2</sub> = 781.25

fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y<sub>1</sub> = 0.00087444

sh<sub>1</sub> = 0.0027982

ft<sub>1</sub> = 327.9137

fy<sub>1</sub> = 273.2614

su<sub>1</sub> = 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/l<sub>d</sub> = 0.14801896

su<sub>1</sub> = 0.4\*esu<sub>1\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>1\_nominal</sub> = 0.08,

For calculation of esu<sub>1\_nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + fs<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 273.2614

with Es<sub>1</sub> = (Es<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + Es<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 200000.00

y<sub>2</sub> = 0.00087444

sh<sub>2</sub> = 0.0027982

ft<sub>2</sub> = 327.9137

fy<sub>2</sub> = 273.2614

su<sub>2</sub> = 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/l<sub>b,min</sub> = 0.14801896

su<sub>2</sub> = 0.4\*esu<sub>2\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>2\_nominal</sub> = 0.08,

For calculation of esu<sub>2\_nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TBDY.

y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + fs<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 273.2614

with Es<sub>2</sub> = (Es<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + Es<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 200000.00

y<sub>v</sub> = 0.00087444

sh<sub>v</sub> = 0.0027982

ft<sub>v</sub> = 327.9137

fy<sub>v</sub> = 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/l<sub>d</sub> = 0.14801896

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsy<sub>v</sub> = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv<sub>nominal</sub> and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsy<sub>v</sub> = 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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$

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

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

$c$  = confinement factor = 1.09425

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02491213$

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  $lb/ld$

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 local axis

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

$n = 12.00$

-----  
Calculation of  $Mu_1$ -

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.0099875$

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

$psh_{min} \cdot Fy_{we} = \text{Min}(psh_x \cdot Fy_{we}, psh_y \cdot Fy_{we}) = 3.11493$

$psh_x \cdot Fy_{we} = psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2} = 3.11493$

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

$psh_y \cdot Fy_{we} = psh1 \cdot Fy_{we1} + ps2 \cdot Fy_{we2} = 3.11493$

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

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 =  $l_b / l_d = 0.14801896$

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

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

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

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

with  $fs1 = (fs_{jacket} \cdot A_{s1,ten,jacket} + fs_{core} \cdot A_{s1,ten,core}) / A_{s1,ten} = 273.2614$

with  $Es1 = (Es_{jacket} \cdot A_{s1,ten,jacket} + Es_{core} \cdot A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

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 =  $l_b / l_{b,min} = 0.14801896$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 273.2614$   
 with  $Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00087444$   
 $shv = 0.0027982$   
 $ftv = 327.9137$   
 $fyv = 273.2614$   
 $suv = 0.0027982$   
 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  
 $lo/lo_{u,min} = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 273.2614$   
 with  $Es_v = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.05655989$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.05655989$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07045463$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07045463$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - 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  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$\mu_{2+} = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$$\mu_{we} \text{ (5.4c)} = 0.02630475$$

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

$$\mu_{ase1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

$$\mu_{psh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

$$\mu_{psh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

$$\mu_{psh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

$$\mu_{psh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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)

$= 1$

$db = 16.66667$

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  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_2 = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of  $\mu_2$ :  $\mu_2^* = \text{shear\_factor} \cdot \text{Max}(\mu_2, cc) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_2 = 0.0099875$

$\mu_2$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

$psh, \min \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h_2 = 250.00$

$psh_y \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

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

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 450.00$$

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

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

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

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

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.14801896$$

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

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

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

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

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

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  $l_b/d$

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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

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

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

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

$$n = 12.00$$

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

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

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

$$V_{Co10} = 575966.892$$

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

-----  
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 (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)

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

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

where:

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: 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)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8*h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: 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,  $\gamma = 1.00$

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,  $M = -2.8989E+007$

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:  $A_{sl} = 1137.257$

-Compression:  $A_{sc} = 1539.38$

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,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.04047263$

$u = \gamma + \rho = 0.04047263$

- Calculation of  $\gamma$  -

$\gamma = (My * Ls / 3) / E_{eff} = 0.00453093$  ((4.29), Biskinis Phd))

$My = 1.1954E+008$

$L_s = M/V$  (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  $\rho_y$  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  $pt = 0.00398711$

$pc = 0.00620943$

$pv = 0.0021956$

$N = 7502.943$

$b = 450.00$

$\rho = 0.10565111$

$y_{comp} = 1.9895870E-005$

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  $l_b/d$

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

$l_b = 300.00$

$l_d = 1621.414$

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)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 3.43481$

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

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

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

$n = 12.00$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.0359417$

with:

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

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 30.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 625.00$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 625.00$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

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

At local axis: 3

Integration Section: (a)  
-----

## Calculation No. 13

column C1, Floor 1

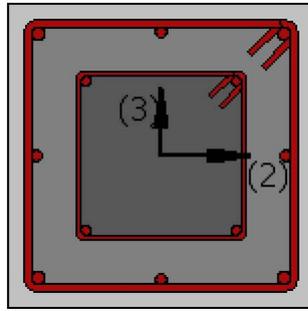
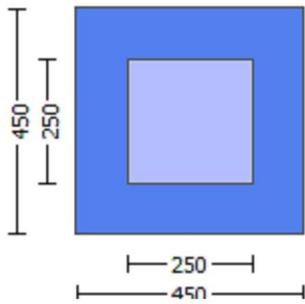
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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,  $M_b = 0.02625938$

Shear Force,  $V_b = 9660.785$

BOTH EDGES

Axial Force,  $F = -7502.943$

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:  $A_{st,mid} = 402.1239$

Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 464717.306$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI0} = 464717.306$

$V_{CoI} = 464717.306$

$k_n = 1.00$

$displacement\_ductility\_demand = 0.36371009$

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)

$M/Vd = 2.00$

$M_u = 0.02625938$

$V_u = 9660.785$

$d = 0.8 \cdot h = 360.00$

$N_u = 7502.943$

$A_g = 202500.00$

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  $\phi / y$

- Calculation of  $\phi / y$  for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 0.00016475

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00045298$  ((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  
Ag = 202500.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$   
N = 7502.943  
 $E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 8.7969E+013$

-----  
Calculation of Yielding Moment My

-----  
Calculation of  $y$  and My according to Annex 7 -

-----  
 $y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 4.2170387E-006$   
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  
 $y_{\text{comp}} = 1.9895870E-005$   
with  $f_c = 30.00$   
Ec = 25742.96  
y = 0.25904663  
A = 0.01451681  
B = 0.00807924  
with Es = 200000.00

-----  
Calculation of ratio  $l_b/d$

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

$l_b = 300.00$

$l_d = 1621.414$

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

$l_{d,\text{min}}$  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

Ktr = 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. 14

column C1, Floor 1

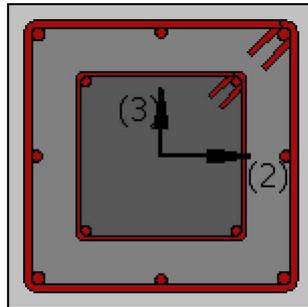
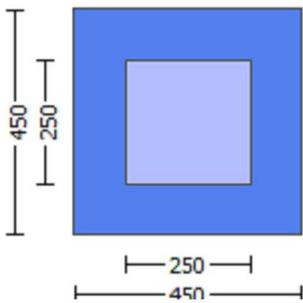
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

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  $135^\circ$ )  
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  
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.3261E+008$   
 $\mu_{u1+} = 1.3261E+008$ , 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  $\mu_{u1+}$   
-----

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

-----  
with full section properties:

$b = 450.00$   
 $d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $f_c = 30.00$   
 $\alpha_1 (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0099875$

$w_e$  (5.4c) = 0.02630475  
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$   
 $a_{se1} = 0.2533421$   
 $b_{o\_1} = 390.00$   
 $h_{o\_1} = 390.00$   
 $b_{i2\_1} = 608400.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$   
 $b_{o\_2} = 242.00$   
 $h_{o\_2} = 242.00$   
 $b_{i2\_2} = 234256.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 450.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 No stirups,  $n_{s\_2} = 2.00$   
 $h_2 = 250.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 450.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 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:  $c_c = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$

$y_1 = 0.00087444$   
 $sh_1 = 0.0027982$   
 $ft_1 = 327.9137$   
 $fy_1 = 273.2614$   
 $su_1 = 0.0027982$

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

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

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

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

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

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

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

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

$y_2 = 0.00087444$   
 $sh_2 = 0.0027982$   
 $ft_2 = 327.9137$   
 $fy_2 = 273.2614$   
 $su_2 = 0.0027982$

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

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

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

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

For calculation of  $es_{u2\_nominal}$  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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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

$lo/lo_{u,min} = lb/ld = 0.14801896$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5,5), TBDY) = 0.032$

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

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

$y_1$ ,  $sh_{1,ft1,fy1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

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

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

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

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

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

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23123015$

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

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

-----  
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:  $f_y = 781.25$

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 local axis

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

$n = 12.00$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

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

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

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

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

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

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

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

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

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

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

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

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

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

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

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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 = 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/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 local axis

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

$n = 12.00$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

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

Final value of  $\phi_c$ :  $\phi_c = \text{shear\_factor} \cdot \max(\phi_c, \phi_c) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

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

$\omega_e$  (5.4c) = 0.02630475

$\omega_e$  (5.4d), TBDY) =  $(\omega_e1 \cdot A_{ext} + \omega_e2 \cdot A_{int}) / A_{sec} = 0.2533421$

$\omega_e1 = 0.2533421$

$b_{o_1} = 390.00$

$h_{o_1} = 390.00$

$b_{i_1} = 608400.00$

$\omega_e2 = \max(\omega_e1, \omega_e2) = 0.2533421$

$b_{o_2} = 242.00$

$h_{o_2} = 242.00$

$b_{i_2} = 234256.00$

$\phi_{sh, \min} \cdot F_{ywe} = \min(\phi_{sh, x} \cdot F_{ywe}, \phi_{sh, y} \cdot F_{ywe}) = 3.11493$

$\phi_{sh, x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

$\phi_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 450.00$

$\phi_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 250.00$

$\phi_{sh, y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.11493$

$\phi_{sh1}$  (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,  $ns_1 = 2.00$   
 $h1 = 450.00$   
 $ps2$  (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.

$y1, sh1, ft1, fy1$ , 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:

$$b = 390.00$$

$$d = 377.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 32.82751$$

$$cc \text{ (5A.5, TBDY)} = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.07045463$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07045463$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.02491213$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u \text{ (4.9)} = 0.23123015$$

$$M_u = M_{Rc} \text{ (4.14)} = 1.3261E+008$$

$$u = s_u \text{ (4.1)} = 8.9430876E-006$$

-----  
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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 12.00$$

-----  
Calculation of  $M_u$

-----  
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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

ho\_1 = 390.00  
bi2\_1 = 608400.00  
ase2 = 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,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  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00087444$   
 $sh_v = 0.0027982$   
 $ft_v = 327.9137$   
 $fy_v = 273.2614$   
 $su_v = 0.0027982$   
 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  
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 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:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 32.82751$   
 $cc(5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

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 Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

-----  
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) ' $Vs = Av * fy * d / s$ ' 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  $fc'^{0.5} \leq 8.3$   
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:  $Vs = Vs1 + Vs2 = 353429.174$

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:  $Vs + Vf \leq 589443.792$

$bw = 450.00$

-----  
Calculation of Shear Strength at edge 2,  $Vr2 = 575966.892$

$Vr2 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 575966.892$

$knl = 1$  (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  $fc'^{0.5} \leq 8.3$   
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:  $Vs = Vs1 + Vs2 = 353429.174$

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, 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:  $As_{,ten} = 1137.257$

-Compression:  $As_{,com} = 1137.257$

-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 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  $\phi_u$  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, TBDY) = 0.002

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)

From (5.4b), TBDY:  $\phi_u = 0.0099875$

$w_e$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

$psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 3.11493$

$psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = Astir_1 * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = Astir_2 * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.11493  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00349066  
Ash<sub>1</sub> = Astir<sub>1</sub>\*ns<sub>1</sub> = 157.0796  
No stirups, ns<sub>1</sub> = 2.00  
h<sub>1</sub> = 450.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00049645  
Ash<sub>2</sub> = Astir<sub>2</sub>\*ns<sub>2</sub> = 100.531  
No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

Asec = 202500.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 781.25

fywe<sub>2</sub> = 781.25

fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y<sub>1</sub> = 0.00087444

sh<sub>1</sub> = 0.0027982

ft<sub>1</sub> = 327.9137

fy<sub>1</sub> = 273.2614

su<sub>1</sub> = 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/l<sub>d</sub> = 0.14801896

su<sub>1</sub> = 0.4\*esu<sub>1\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>1\_nominal</sub> = 0.08,

For calculation of esu<sub>1\_nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + fs<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 273.2614

with Es<sub>1</sub> = (Es<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + Es<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 200000.00

y<sub>2</sub> = 0.00087444

sh<sub>2</sub> = 0.0027982

ft<sub>2</sub> = 327.9137

fy<sub>2</sub> = 273.2614

su<sub>2</sub> = 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/l<sub>b,min</sub> = 0.14801896

su<sub>2</sub> = 0.4\*esu<sub>2\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>2\_nominal</sub> = 0.08,

For calculation of esu<sub>2\_nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TBDY.

y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + fs<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 273.2614

with Es<sub>2</sub> = (Es<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + Es<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 200000.00

y<sub>v</sub> = 0.00087444

sh<sub>v</sub> = 0.0027982

ft<sub>v</sub> = 327.9137

fy<sub>v</sub> = 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/l<sub>d</sub> = 0.14801896

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsy<sub>v</sub> = fs<sub>v</sub>/1.2, from table 5.1, TBDY  
For calculation of esuv<sub>nominal</sub> and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsy<sub>v</sub> = fs<sub>v</sub>/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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

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

$c$  = confinement factor = 1.09425

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02491213$

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 local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 12.00$

-----  
Calculation of  $Mu_1$ -

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0099875$

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) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o\_1} = 390.00$

$h_{o\_1} = 390.00$

$b_{i2\_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o\_2} = 242.00$

$h_{o\_2} = 242.00$

$b_{i2\_2} = 234256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

From ((5.A.5), TBDY), TBDY:  $c_c = 0.0029425$

$c$  = 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

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 * e_{su1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1\_nominal} = 0.08$ ,

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_s / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, 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  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 273.2614$   
 with  $Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00087444$   
 $shv = 0.0027982$   
 $ftv = 327.9137$   
 $fyv = 273.2614$   
 $suv = 0.0027982$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 273.2614$   
 with  $Es_v = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.05655989$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.05655989$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = confinement\ factor = 1.09425$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07045463$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07045463$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.02491213$   
 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  $lb/ld$   
 -----  
 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  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$\mu_{2+} = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_{cu}: \mu_{cu} = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.0099875$$

$$\mu_{we} \text{ (5.4c)} = 0.02630475$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.2533421$$

$$\mu_{ase1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

$$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.2533421$$

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 3.11493$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.11493$$

$$\mu_{psh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

$$\mu_{psh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.11493$$

$$\mu_{psh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

$$\mu_{psh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \mu_{cc} = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou,min = lb/ld = 0.14801896$$

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 273.2614$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.00087444$$

$$sh2 = 0.0027982$$

$$ft2 = 327.9137$$

$$fy2 = 273.2614$$

$$su2 = 0.0027982$$

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

$$lo/lou,min = lb/lb,min = 0.14801896$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 273.2614$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.00087444$$

$$shv = 0.0027982$$

$$ftv = 327.9137$$

$$fyv = 273.2614$$

$$suv = 0.0027982$$

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

$$lo/lou,min = lb/ld = 0.14801896$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 273.2614$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908$$

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 < vs,y2 - LHS eq.(4.5) is satisfied

---

$$su (4.9) = 0.23123015$$

$$\mu_u = MRc (4.14) = 1.3261E+008$$

$$u = su (4.1) = 8.9430876E-006$$

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  $\mu_u$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$\mu_u = 8.9430876E-006$

$\mu_u = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

$cc$  (5A.5, TBDY) = 0.002

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, cc) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.0099875$

$\mu_u$  (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) =  $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h1 = 450.00$

$ps2$  (internal) =  $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 450.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.14801896$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

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  $l_b/d$

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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 12.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 575966.892$

$$V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = k_{nl} * V_{Co10}$$

$$V_{Co10} = 575966.892$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

-----  
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).

-----  
 $= 1$  (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)

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

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: 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)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8*h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: 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,  $\gamma = 1.00$

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,  $M = 2.2636163E-010$

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:  $A_{sl} = 0.00$

-Compression:  $A_{sc} = 2676.637$

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,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.03820662$

$u = \gamma + \rho = 0.03820662$

- Calculation of  $\gamma$  -

$\gamma = (My * Ls / 3) / E_{eff} = 0.00226492$  ((4.29), Biskinis Phd))

$My = 1.1954E+008$

$L_s = M/V$  (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  $\rho_y$  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 local axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 12.00$

- Calculation of  $\rho_p$  -

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 30.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 625.00$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 625.00$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

-----  
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

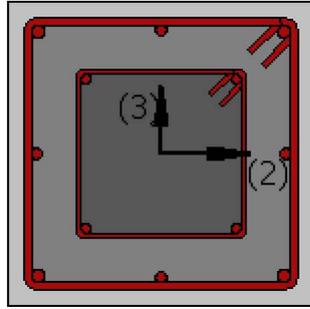
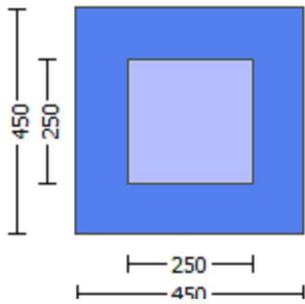
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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  $\gamma$  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,  $f_c = f_{cm} = 30.00$

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\*VColO = 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:  $f_c' = (f_{c'}\text{_{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c'}\text{_{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 30.00$   
N = 7502.943  
 $E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 8.7969E+013$

-----  
-----  
Calculation of Yielding Moment  $M_y$

-----  
Calculation of  $f_y$  and  $M_y$  according to Annex 7 -

-----  
 $y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 4.2170387E-006$   
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  
 $y_{\text{comp}} = 1.9895870E-005$   
with  $f_c = 30.00$   
Ec = 25742.96  
y = 0.25904663  
A = 0.01451681  
B = 0.00807924  
with Es = 200000.00

-----  
-----  
Calculation of ratio  $l_b/d$

-----  
Lap Length:  $l_d/l_{d,\text{min}} = 0.1850237$   
 $l_b = 300.00$   
 $l_d = 1621.414$   
Calculation of  $l$  according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.  
 $l_{d,\text{min}}$  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  
Ktr = 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: 3

Integration Section: (b)

-----

## Calculation No. 16

column C1, Floor 1

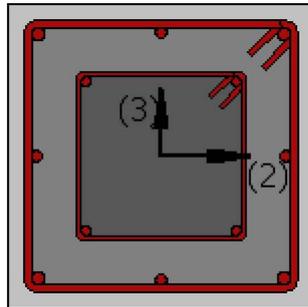
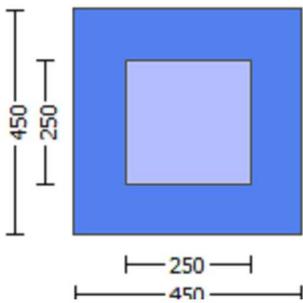
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

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  $135^\circ$ )  
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:  $A_{st} = 0.00$   
-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:  $A_{st,mid} = 402.1239$

-----  
-----  
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  $\mu_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 8.9430876E-006$   
 $\mu_u = 1.3261E+008$

-----  
with full section properties:

$b = 450.00$   
 $d = 407.00$   
 $d' = 43.00$   
 $v = 0.00136624$   
 $N = 7506.808$   
 $f_c = 30.00$   
 $\alpha_1(5A.5, \text{TBDY}) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.0099875$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.0099875$

$w_e (5.4c) = 0.02630475$   
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.2533421$   
 $ase1 = 0.2533421$   
 $bo\_1 = 390.00$   
 $ho\_1 = 390.00$   
 $bi2\_1 = 608400.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.2533421$   
 $bo\_2 = 242.00$   
 $ho\_2 = 242.00$   
 $bi2\_2 = 234256.00$   
 $psh, \min \cdot Fywe = \text{Min}(psh, x \cdot Fywe, psh, y \cdot Fywe) = 3.11493$

$psh, x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.11493$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 450.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 250.00$

$psh, y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 3.11493$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00349066$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 450.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00049645$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 250.00$

$A_{sec} = 202500.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$fywe1 = 781.25$   
 $fywe2 = 781.25$   
 $fce = 30.00$

$\text{From } ((5.A5), TBDY), TBDY: cc = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$

$y1 = 0.00087444$   
 $sh1 = 0.0027982$   
 $ft1 = 327.9137$   
 $fy1 = 273.2614$   
 $su1 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$lo/lou, \min = lb/ld = 0.14801896$

$su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$

$\text{From table 5A.1, TBDY: } esu1\_nominal = 0.08,$

$\text{For calculation of } esu1\_nominal \text{ and } y1, sh1, ft1, fy1, \text{ it is considered}$   
 $\text{characteristic value } fsy1 = fs1 / 1.2, \text{ from table 5.1, TBDY.}$

$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$

$\text{with } fs1 = (fs_{jacket} \cdot A_{sl, ten, jacket} + fs_{core} \cdot A_{sl, ten, core}) / A_{sl, ten} = 273.2614$

$\text{with } Es1 = (Es_{jacket} \cdot A_{sl, ten, jacket} + Es_{core} \cdot A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.00087444$   
 $sh2 = 0.0027982$   
 $ft2 = 327.9137$   
 $fy2 = 273.2614$   
 $su2 = 0.0027982$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$lo/lou, \min = lb/lb, \min = 0.14801896$

$su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$

$\text{From table 5A.1, TBDY: } esu2\_nominal = 0.08,$

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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , 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

$lo/lo_{u,min} = lb/ld = 0.14801896$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{uv\_nominal} = 0.08$ ,

considering characteristic value  $fs_{yv} = f_{sv}/1.2$ , 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  $fs_{yv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_{1,ft1,fy1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 273.2614$

with  $Es_v = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.05655989$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05655989$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.01999908$

and confined core properties:

$b = 390.00$

$d = 377.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 32.82751$

$cc (5A.5, TBDY) = 0.0029425$

$c = \text{confinement factor} = 1.09425$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.23123015$

$\mu_u = MR_c (4.14) = 1.3261E+008$

$u = su (4.1) = 8.9430876E-006$

-----  
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:  $f_y = 781.25$

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 Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 8.9430876E-006$$

$$Mu = 1.3261E+008$$

with full section properties:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o\_1} = 390.00$$

$$h_{o\_1} = 390.00$$

$$b_{i2\_1} = 608400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$$

$$b_{o\_2} = 242.00$$

$$h_{o\_2} = 242.00$$

$$b_{i2\_2} = 234256.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00349066$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 450.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00049645$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 250.00$$

$$A_{sec} = 202500.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 781.25$$

$$f_{ywe2} = 781.25$$

$$f_{ce} = 30.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y_1 = 0.00087444$$

$$sh_1 = 0.0027982$$

$$ft_1 = 327.9137$$

$$fy_1 = 273.2614$$

$$su_1 = 0.0027982$$

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

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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{d})^{2/3})$ , 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 = 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/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 local axis

$s = \max(s_{external}, s_{internal}) = 250.00$

$n = 12.00$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  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  $\mu_u$ :  $\mu_u^* = shear\_factor \cdot \max(\mu_u, \mu_c) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.0099875$

$w_e$  (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) =  $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h1 = 450.00$

$ps2$  (internal) =  $(A_{sh2} \cdot h2 / s2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h2 = 250.00$

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.11493$

$ps1$  (external) =  $(A_{sh1} \cdot h1 / s1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

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

$lo/lou,min = lb/ld = 0.14801896$   
 $su1 = 0.4*esu1\_nominal$  ((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  $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$

$1 = Asl,ten/(b*d)*(fs1/fc) = 0.05655989$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.05655989$

$v = Asl,mid/(b*d)*(fsv/fc) = 0.01999908$

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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 12.00$$

Calculation of  $M_u$

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:

$$b = 450.00$$

$$d = 407.00$$

$$d' = 43.00$$

$$v = 0.00136624$$

$$N = 7506.808$$

$$f_c = 30.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.0099875$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.0099875$$

$$w_e \text{ (5.4c)} = 0.02630475$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$$

$$a_{se1} = 0.2533421$$

$$b_{o_1} = 390.00$$

ho\_1 = 390.00  
bi2\_1 = 608400.00  
ase2 = 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,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  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00087444$   
 $sh_v = 0.0027982$   
 $ft_v = 327.9137$   
 $fy_v = 273.2614$   
 $su_v = 0.0027982$   
 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  
 $l_o/l_{o,min} = l_b/l_d = 0.14801896$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 273.2614$   
 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:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 32.82751$   
 $cc(5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07045463$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07045463$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

#### 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 Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 575966.892$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$

$V_{ColO} = 575966.892$

$kn1 = 1$  (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  $Col2 = 0.00$

$s/d = 1.25$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 589443.792$

$bw = 450.00$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 575966.892$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$

$V_{ColO} = 575966.892$

$kn1 = 1$  (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:  $As_{ten} = 1137.257$

-Compression:  $As_{com} = 1137.257$

-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 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  $\phi_u$  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, TBDY) = 0.002

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)

From (5.4b), TBDY:  $\phi_u = 0.0099875$

$w_e$  (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) =  $(A_{sh1} * h1 / s1) / A_{sec} = 0.00349066$

$A_{sh1} = Astir_1 * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h1 = 450.00$

$ps2$  (internal) =  $(A_{sh2} * h2 / s2) / A_{sec} = 0.00049645$

$A_{sh2} = Astir_2 * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.11493  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00349066  
Ash<sub>1</sub> = Astir<sub>1</sub>\*ns<sub>1</sub> = 157.0796  
No stirups, ns<sub>1</sub> = 2.00  
h<sub>1</sub> = 450.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00049645  
Ash<sub>2</sub> = Astir<sub>2</sub>\*ns<sub>2</sub> = 100.531  
No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 250.00

Asec = 202500.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 781.25

fywe<sub>2</sub> = 781.25

fce = 30.00

From ((5.A.5), TBDY), TBDY: cc = 0.0029425

c = confinement factor = 1.09425

y<sub>1</sub> = 0.00087444

sh<sub>1</sub> = 0.0027982

ft<sub>1</sub> = 327.9137

fy<sub>1</sub> = 273.2614

su<sub>1</sub> = 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/l<sub>d</sub> = 0.14801896

su<sub>1</sub> = 0.4\*esu<sub>1\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>1\_nominal</sub> = 0.08,

For calculation of esu<sub>1\_nominal</sub> and y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, it is considered  
characteristic value fsy<sub>1</sub> = fs<sub>1</sub>/1.2, from table 5.1, TBDY.

y<sub>1</sub>, sh<sub>1</sub>,ft<sub>1</sub>,fy<sub>1</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + fs<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 273.2614

with Es<sub>1</sub> = (Es<sub>jacket</sub>\*Asl<sub>ten,jacket</sub> + Es<sub>core</sub>\*Asl<sub>ten,core</sub>)/Asl<sub>ten</sub> = 200000.00

y<sub>2</sub> = 0.00087444

sh<sub>2</sub> = 0.0027982

ft<sub>2</sub> = 327.9137

fy<sub>2</sub> = 273.2614

su<sub>2</sub> = 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/l<sub>b,min</sub> = 0.14801896

su<sub>2</sub> = 0.4\*esu<sub>2\_nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu<sub>2\_nominal</sub> = 0.08,

For calculation of esu<sub>2\_nominal</sub> and y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, it is considered  
characteristic value fsy<sub>2</sub> = fs<sub>2</sub>/1.2, from table 5.1, TBDY.

y<sub>2</sub>, sh<sub>2</sub>,ft<sub>2</sub>,fy<sub>2</sub>, are also multiplied by Min(1,1.25\*(lb/l<sub>d</sub>)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + fs<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 273.2614

with Es<sub>2</sub> = (Es<sub>jacket</sub>\*Asl<sub>com,jacket</sub> + Es<sub>core</sub>\*Asl<sub>com,core</sub>)/Asl<sub>com</sub> = 200000.00

y<sub>v</sub> = 0.00087444

sh<sub>v</sub> = 0.0027982

ft<sub>v</sub> = 327.9137

fy<sub>v</sub> = 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/l<sub>d</sub> = 0.14801896

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsy<sub>v</sub> = fs<sub>v</sub>/1.2, from table 5.1, TBDY  
For calculation of esuv<sub>nominal</sub> and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsy<sub>v</sub> = fs<sub>v</sub>/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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 273.2614$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.05655989$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05655989$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.01999908$

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

$c$  = confinement factor = 1.09425

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07045463$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07045463$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.02491213$

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  $lb/ld$

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 local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 12.00$

-----  
Calculation of  $Mu_1$ -

-----  
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  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.0099875$

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) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.2533421$

$a_{se1} = 0.2533421$

$b_{o\_1} = 390.00$

$h_{o\_1} = 390.00$

$b_{i2\_1} = 608400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.2533421$

$b_{o\_2} = 242.00$

$h_{o\_2} = 242.00$

$b_{i2\_2} = 234256.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.11493$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.11493$

$p_{s1}$  (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,  $n_{s\_2} = 2.00$

$h_2 = 250.00$

$A_{sec} = 202500.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 781.25$

$f_{ywe2} = 781.25$

$f_{ce} = 30.00$

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

$l_o / l_{ou, \min} = l_b / l_d = 0.14801896$

$su_1 = 0.4 * e_{su1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1\_nominal} = 0.08$ ,

For calculation of  $e_{su1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
characteristic value  $f_{sy1} = f_s / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, 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  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00087444$

$sh_2 = 0.0027982$

$ft_2 = 327.9137$

$fy_2 = 273.2614$

$su_2 = 0.0027982$

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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs\_jacket * Asl\_com\_jacket + fs\_core * Asl\_com\_core) / Asl\_com = 273.2614$   
 with  $Es_2 = (Es\_jacket * Asl\_com\_jacket + Es\_core * Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00087444$   
 $shv = 0.0027982$   
 $ftv = 327.9137$   
 $fyv = 273.2614$   
 $suv = 0.0027982$   
 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  
 $lo/lo_{u,min} = lb/ld = 0.14801896$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 273.2614$   
 with  $Es_v = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.05655989$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.05655989$   
 $v = Asl\_mid / (b * d) * (fs_v / fc) = 0.01999908$   
 and confined core properties:  
 $b = 390.00$   
 $d = 377.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 32.82751$   
 $cc (5A.5, TBDY) = 0.0029425$   
 $c = \text{confinement factor} = 1.09425$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.07045463$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.07045463$   
 $v = Asl\_mid / (b * d) * (fs_v / fc) = 0.02491213$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - 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  $\phi_u$  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<sub>c</sub> = 30.00

co (5A.5, TBDY) = 0.002

Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_{cu} = 0.0099875$

we (5.4c) = 0.02630475

ase ((5.4d), TBDY) =  $(\text{ase1} * A_{\text{ext}} + \text{ase2} * A_{\text{int}}) / A_{\text{sec}} = 0.2533421$

ase1 = 0.2533421

bo\_1 = 390.00

ho\_1 = 390.00

bi2\_1 = 608400.00

ase2 =  $\text{Max}(\text{ase1}, \text{ase2}) = 0.2533421$

bo\_2 = 242.00

ho\_2 = 242.00

bi2\_2 = 234256.00

$\text{psh}_{\text{min}} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 3.11493$

$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{psh}_2 * F_{ywe2} = 3.11493$

ps1 (external) =  $(A_{sh1} * h_1 / s_1) / A_{\text{sec}} = 0.00349066$

Ash1 =  $A_{\text{stir}_1} * n_{s1} = 157.0796$

No stirups,  $n_{s1} = 2.00$

h1 = 450.00

ps2 (internal) =  $(A_{sh2} * h_2 / s_2) / A_{\text{sec}} = 0.00049645$

Ash2 =  $A_{\text{stir}_2} * n_{s2} = 100.531$

No stirups,  $n_{s2} = 2.00$

h2 = 250.00

$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{psh}_2 * F_{ywe2} = 3.11493$

ps1 (external) =  $(A_{sh1} * h_1 / s_1) / A_{\text{sec}} = 0.00349066$

Ash1 =  $A_{\text{stir}_1} * n_{s1} = 157.0796$

No stirups,  $n_{s1} = 2.00$

h1 = 450.00

ps2 (internal) =  $(A_{sh2} * h_2 / s_2) / A_{\text{sec}} = 0.00049645$

Ash2 =  $A_{\text{stir}_2} * n_{s2} = 100.531$

No stirups,  $n_{s2} = 2.00$

h2 = 250.00

Asec = 202500.00

s1 = 100.00

s2 = 250.00

f<sub>ywe1</sub> = 781.25

f<sub>ywe2</sub> = 781.25

f<sub>ce</sub> = 30.00

From ((5.A.5), 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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/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  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , 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)

$= 1$

$db = 16.66667$

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  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 8.9430876E-006$

$\mu_2 = 1.3261E+008$

with full section properties:

$b = 450.00$

$d = 407.00$

$d' = 43.00$

$v = 0.00136624$

$N = 7506.808$

$f_c = 30.00$

$cc$  (5A.5, TBDY) = 0.002

Final value of  $\mu_2$ :  $\mu_2^* = \text{shear\_factor} \cdot \text{Max}(\mu_2, cc) = 0.0099875$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_2 = 0.0099875$

$\mu_2$  (5.4c) = 0.02630475

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.2533421$

$ase_1 = 0.2533421$

$bo_1 = 390.00$

$ho_1 = 390.00$

$bi_2_1 = 608400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.2533421$

$bo_2 = 242.00$

$ho_2 = 242.00$

$bi_2_2 = 234256.00$

$psh, \min \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.11493$

$psh_x \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

$ps_1$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00349066$

$A_{sh1} = A_{stir_1} \cdot ns_1 = 157.0796$

No stirrups,  $ns_1 = 2.00$

$h_1 = 450.00$

$ps_2$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00049645$

$A_{sh2} = A_{stir_2} \cdot ns_2 = 100.531$

No stirrups,  $ns_2 = 2.00$

$h_2 = 250.00$

$psh_y \cdot F_{ywe} = psh_1 \cdot F_{ywe1} + psh_2 \cdot F_{ywe2} = 3.11493$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00349066$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 450.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00049645$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 250.00$$

$$Asec = 202500.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 781.25$$

$$fywe2 = 781.25$$

$$fce = 30.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.0029425$$

$$c = \text{confinement factor} = 1.09425$$

$$y1 = 0.00087444$$

$$sh1 = 0.0027982$$

$$ft1 = 327.9137$$

$$fy1 = 273.2614$$

$$su1 = 0.0027982$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.14801896$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

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

$$lo/lou, \text{min} = lb/ld = 0.14801896$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

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  $l_b/d$

-----  
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)

$$= 1$$

$$d_b = 16.66667$$

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)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 3.43481$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$$

where  $A_{tr,x}$ ,  $A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 12.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 575966.892$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 575966.892$

$$V_{r1} = V_{Co1} ((10.3), ASCE 41-17) = k_{nl} * V_{Co10}$$

$$V_{Co10} = 575966.892$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

-----  
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 (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)

$$M/Vd = 2.00$$

$$M_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8 * h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 353429.174$$

where:

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

$$b_w = 450.00$$

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: 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)

$$M/Vd = 2.00$$

$$\mu_u = 2.0434592E-012$$

$$V_u = 2.9582284E-031$$

$$d = 0.8*h = 360.00$$

$$N_u = 7506.808$$

$$A_g = 202500.00$$

From (11.5.4.8), ACI 318-14: 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

$$b_w = 450.00$$

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,  $M = 0.02625938$

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:  $A_{sl} = 0.00$

-Compression:  $A_{sc} = 2676.637$

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,  $DbL = 16.80$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.03639469$

$u = \gamma + p = 0.03639469$

- Calculation of  $\gamma$  -

$\gamma = (My * Ls / 3) / E_{eff} = 0.00045298$  ((4.29), Biskinis Phd))

$My = 1.1954E+008$

$L_s = M/V$  (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  $\rho_y$  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 local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 12.00$

- Calculation of  $\rho_p$  -

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.

$$N_{UD} = 7502.943$$

$$A_g = 202500.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 30.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 625.00$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 625.00$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01461445$$

$$b = 450.00$$

$$d = 407.00$$

$$f_{cE} = 30.00$$

-----  
End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

-----