

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

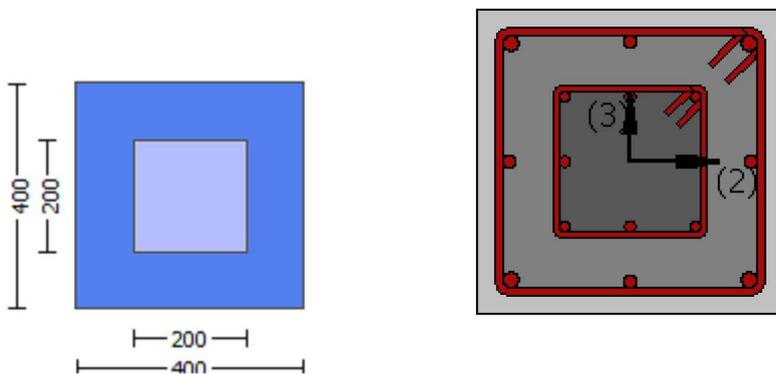
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

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Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of  $\gamma$  for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
#####
External Height, H = 400.00
External Width, W = 400.00
Internal Height, H = 200.00
Internal Width, W = 200.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping
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Stepwise Properties
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EDGE -A-
Bending Moment, Ma = -2.0483E+007
Shear Force, Va = -6825.705
EDGE -B-
Bending Moment, Mb = -0.01979425
Shear Force, Vb = 6825.705
BOTH EDGES
Axial Force, F = -6023.953
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Aslt = 1291.195
  -Compression: Aslc = 2001.195
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension: Asl,ten = 1291.195
  -Compression: Asl,com = 1291.195
  -Middle: Asl,mid = 709.9999
Mean Diameter of Tension Reinforcement, DbL,ten = 16.33333
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New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 331644.008
Vn ((10.3), ASCE 41-17) = knl*VCol = 331644.008
VCol = 331644.008
knl = 1.00
displacement_ductility_demand = 0.0460526
-----
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 = 25.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

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$M/Vd = 4.00$   
 $\mu = 2.0483E+007$   
 $V_u = 6825.705$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 6023.953$   
 $A_g = 160000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$   
 where:  
 $V_{s1} = 251327.412$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 425154.451$   
 $b_w = 400.00$

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

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

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 From analysis, chord rotation  $\theta = 0.00033528$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00728036$  ((4.29), Biskinis Phd)  
 $M_y = 1.2576E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3000.884  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.7280E+013$   
 $factor = 0.30$   
 $A_g = 160000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$   
 $N = 6023.953$   
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 5.7599E+013$

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 Calculation of Yielding Moment  $M_y$

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 Calculation of  $\delta / y$  and  $M_y$  according to Annex 7 -

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 $y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.2162520E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/d)^{2/3}) = 260.4851$   
 $d = 357.00$   
 $y = 0.30059914$   
 $A = 0.02321789$   
 $B = 0.01307844$   
 with  $p_t = 0.00904198$   
 $p_c = 0.00904198$   
 $p_v = 0.00497199$   
 $N = 6023.953$   
 $b = 400.00$   
 $\lambda = 0.12044818$   
 $y_{comp} = 2.0592201E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.29926824$

A = 0.02296007  
B = 0.0129165  
with Es = 200000.00

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_d/l_{d,min} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

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

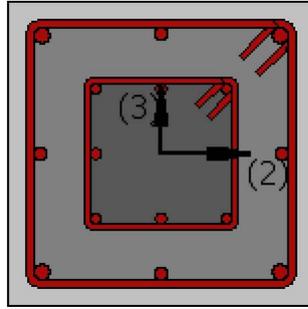
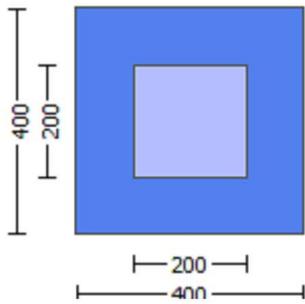
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

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External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.03547

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -1.0996693E-030$

EDGE -B-

Shear Force,  $V_b = 1.0996693E-030$

BOTH EDGES

Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1291.195$   
-Compression:  $As_{c,com} = 1291.195$   
-Middle:  $As_{c,mid} = 709.9999$

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Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4747E+008$   
 $Mu_{1+} = 1.4747E+008$ , 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  
 $Mu_{1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4747E+008$   
 $Mu_{2+} = 1.4747E+008$ , 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  
 $Mu_{2-} = 1.4747E+008$ , 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

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Calculation of  $Mu_{1+}$   
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Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 1.1814054E-005$   
 $M_u = 1.4747E+008$

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with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\phi_c$  (5A.5, TBDY) = 0.002  
Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\phi_u = 0.00951404$   
 $\phi_u$  (5.4c) = 0.02260544  
 $\phi_u$  ((5.4d), TBDY) =  $(\phi_{u1} * A_{ext} + \phi_{u2} * A_{int}) / A_{sec} = 0.24250288$   
 $\phi_{u1} = 0.24250288$   
 $b_{o,1} = 340.00$   
 $h_{o,1} = 340.00$   
 $b_{i,1} = 462400.00$   
 $\phi_{u2} = \text{Max}(\phi_{u1}, \phi_{u2}) = 0.24250288$   
 $b_{o,2} = 192.00$   
 $h_{o,2} = 192.00$   
 $b_{i,2} = 147456.00$   
 $\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 3.07617$

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 $\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.07617$   
 $\phi_{sh1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$   
No stirups,  $n_{s,1} = 2.00$   
 $h_1 = 400.00$   
 $\phi_{sh2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$   
No stirups,  $n_{s,2} = 2.00$

h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y1 = 0.00101015

sh1 = 0.00323248

ft1 = 336.7189

fy1 = 280.5991

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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

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

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

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

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

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 280.5991$   
with  $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$

and confined core properties:

$b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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$su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$   
 $l_d = 1632.369$

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)

$= 1$   
 $db = 16.00$   
Mean strength value of all re-bars:  $f_y = 694.45$   
Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$   
where  $A_{tr,x}, A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

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Calculation of  $Mu1$ -

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

$u = 1.1814054E-005$   
 $Mu = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00951404$   
we (5.4c) = 0.02260544  
ase ((5.4d), TBDY) =  $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.24250288$   
ase1 = 0.24250288  
bo\_1 = 340.00  
ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 =  $\text{Max}(ase1, ase2) = 0.24250288$   
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
 $psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 3.07617$

-----  
 $psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.07617$   
ps1 (external) =  $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00392699$   
Ash1 =  $A_{stir\_1} \cdot ns_1 = 157.0796$   
No stirups,  $ns_1 = 2.00$   
h1 = 400.00  
ps2 (internal) =  $(Ash2 \cdot h2 / s2) / A_{sec} = 0.00050265$   
Ash2 =  $A_{stir\_2} \cdot ns_2 = 100.531$   
No stirups,  $ns_2 = 2.00$   
h2 = 200.00

-----  
 $psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 3.07617$   
ps1 (external) =  $(Ash1 \cdot h1 / s1) / A_{sec} = 0.00392699$   
Ash1 =  $A_{stir\_1} \cdot ns_1 = 157.0796$   
No stirups,  $ns_1 = 2.00$   
h1 = 400.00  
ps2 (internal) =  $(Ash2 \cdot h2 / s2) / A_{sec} = 0.00050265$   
Ash2 =  $A_{stir\_2} \cdot ns_2 = 100.531$   
No stirups,  $ns_2 = 2.00$   
h2 = 200.00

-----  
Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY:  $cc = 0.00235471$   
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

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

lo/lou,min =  $l_b / l_d = 0.18378198$

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  $fs1 = (fs_{jacket} \cdot A_{s,ten,jacket} + fs_{core} \cdot A_{s,ten,core}) / A_{s,ten} = 280.5991$

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

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

lo/lou,min =  $l_b / l_{b,min} = 0.18378198$

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

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

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

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

with  $fs2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 280.5991$

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

$yv = 0.00101015$

$shv = 0.00323248$

$ftv = 336.7189$

$fyv = 280.5991$

$suv = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou,min = lb/d = 0.18378198$

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

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  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 280.5991$

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

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07688397$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.07688397$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09875006$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09875006$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23357771$

$Mu = MRc (4.14) = 1.4747E+008$

$u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/d$

Lap Length:  $lb/d = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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)

$= 1$

$db = 16.00$

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

Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} <= 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 2.57611$

$Atr = Min(Atr\_x, Atr\_y) = 257.6106$

where  $Atr\_x, Atr\_y$  are the sum of the area of all stirrup legs along X and Y local axis

$s = Max(s\_external, s\_internal) = 250.00$

$n = 16.00$

Calculation of Mu2+

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

$$\phi_u = 1.1814054E-005$$

$$\mu_u = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00951404$$

$$\phi_{ue} \text{ (5.4c)} = 0.02260544$$

$$\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.24250288$$

$$\phi_{ase1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 3.07617$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.07617$$

$$\phi_{psh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\phi_{psh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 3.07617$$

$$\phi_{psh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$\phi_{psh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.18378198$$

$$s_u1 = 0.4 * e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s1\_nominal} = 0.08$ ,

For calculation of  $e_{s1\_nominal}$  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.

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 280.5991$$

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

$$y_2 = 0.00101015$$

$$sh_2 = 0.00323248$$

$$ft_2 = 336.7189$$

$$fy_2 = 280.5991$$

$$s_u2 = 0.00323248$$

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

$$l_o/l_{o,min} = l_b/l_{b,min} = 0.18378198$$

$$s_u2 = 0.4 * e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s2\_nominal} = 0.08$ ,

For calculation of  $e_{s2\_nominal}$  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.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 280.5991$$

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

$$y_v = 0.00101015$$

$$sh_v = 0.00323248$$

$$ft_v = 336.7189$$

$$fy_v = 280.5991$$

$$s_uv = 0.00323248$$

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

$$l_o/l_{o,min} = l_b/l_d = 0.18378198$$

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

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

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

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 280.5991$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.07688397$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.07688397$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.09875006$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09875006$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$\mu_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$d_b = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

Calculation of  $\mu_2$

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

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $\phi_c$ :  $\phi_c = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.00951404$

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

From (5.4b), TBDY:  $\phi_c = 0.00951404$

$\phi_w$  (5.4c) = 0.02260544

$\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.24250288$

$\phi_{ase1} = 0.24250288$

$\phi_{bo_1} = 340.00$

$\phi_{ho_1} = 340.00$

$\phi_{bi2_1} = 462400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$

$\phi_{bo_2} = 192.00$

$\phi_{ho_2} = 192.00$

$\phi_{bi2_2} = 147456.00$

$\phi_{psh, \min} \cdot F_{ywe} = \text{Min}(\phi_{psh, x} \cdot F_{ywe}, \phi_{psh, y} \cdot F_{ywe}) = 3.07617$

$\phi_{psh, x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{psh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

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

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 400.00$

$\phi_{psh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

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

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 200.00$

$\phi_{psh, y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{psh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$$h1 = 400.00$$

$$\text{ps2 (internal)} = (\text{Ash2} * h2 / s2) / \text{Asec} = 0.00050265$$

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

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

$$h2 = 200.00$$

---

$$\text{Asec} = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$\text{fywe1} = 694.45$$

$$\text{fywe2} = 694.45$$

$$\text{fce} = 33.00$$

$$\text{From } ((5.5), \text{TBDY}), \text{TBDY: cc} = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$\text{sh1} = 0.00323248$$

$$\text{ft1} = 336.7189$$

$$\text{fy1} = 280.5991$$

$$\text{su1} = 0.00323248$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 0.18378198$$

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

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

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

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

$$\text{with fs1} = (\text{fs,jacket} * \text{Asl,ten,jacket} + \text{fs,core} * \text{Asl,ten,core}) / \text{Asl,ten} = 280.5991$$

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

$$y2 = 0.00101015$$

$$\text{sh2} = 0.00323248$$

$$\text{ft2} = 336.7189$$

$$\text{fy2} = 280.5991$$

$$\text{su2} = 0.00323248$$

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

$$\text{lo/lou,min} = \text{lb/lb,min} = 0.18378198$$

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

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

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

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

$$\text{with fs2} = (\text{fs,jacket} * \text{Asl,com,jacket} + \text{fs,core} * \text{Asl,com,core}) / \text{Asl,com} = 280.5991$$

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

$$yv = 0.00101015$$

$$\text{shv} = 0.00323248$$

$$\text{ftv} = 336.7189$$

$$\text{fyv} = 280.5991$$

$$\text{suv} = 0.00323248$$

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

$$\text{lo/lou,min} = \text{lb/ld} = 0.18378198$$

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

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

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.

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

$$\text{with fsv} = (\text{fs,jacket} * \text{Asl,mid,jacket} + \text{fs,mid} * \text{Asl,mid,core}) / \text{Asl,mid} = 280.5991$$

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

$$1 = \text{Asl,ten} / (\text{b} * \text{d}) * (\text{fs1} / \text{fc}) = 0.07688397$$

$$2 = \text{Asl,com} / (\text{b} * \text{d}) * (\text{fs2} / \text{fc}) = 0.07688397$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$M_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

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

-----  
Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$$V_{Col0} = 463630.789$$

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

-----  
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:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$M_u = 9.7987490E-012$$

$$V_u = 1.0996693E-030$$

$$d = 0.8 * h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

Vs1 = 279254.914 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 488465.275

bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 463630.789

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

VCol0 = 463630.789

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 = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/d = 2.00

Mu = 9.7987490E-012

Vu = 1.0996693E-030

d = 0.8\*h = 320.00

Nu = 6026.684

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914

where:

Vs1 = 279254.914 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 488465.275

bw = 400.00

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.03547

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = 6.7333103E-047$

EDGE -B-

Shear Force,  $V_b = -6.7333103E-047$

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression:  $A_{sl,c} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.4747E+008$

$M_{u1+} = 1.4747E+008$ , 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- = 1.4747E+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-) = 1.4747E+008

Mu2+ = 1.4747E+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- = 1.4747E+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:

$\phi_u = 1.1814054E-005$

Mu = 1.4747E+008

-----  
with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.0012789

N = 6026.684

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$

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

From (5.4b), TBDY:  $\phi_u = 0.00951404$

we (5.4c) = 0.02260544

ase ((5.4d), TBDY) =  $(\text{ase1} * \text{Aext} + \text{ase2} * \text{Aint}) / \text{Asec} = 0.24250288$

ase1 = 0.24250288

bo\_1 = 340.00

ho\_1 = 340.00

bi2\_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288

bo\_2 = 192.00

ho\_2 = 192.00

bi2\_2 = 147456.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

-----  
psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617

ps1 (external) =  $(\text{Ash1} * \text{h1} / \text{s1}) / \text{Asec} = 0.00392699$

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

No stirups, ns\_1 = 2.00

h1 = 400.00

ps2 (internal) =  $(\text{Ash2} * \text{h2} / \text{s2}) / \text{Asec} = 0.00050265$

Ash2 = Astir\_2\*ns\_2 = 100.531

No stirups, ns\_2 = 2.00

h2 = 200.00

-----  
psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617

ps1 (external) =  $(\text{Ash1} * \text{h1} / \text{s1}) / \text{Asec} = 0.00392699$

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

No stirups, ns\_1 = 2.00

h1 = 400.00

ps2 (internal) =  $(\text{Ash2} * \text{h2} / \text{s2}) / \text{Asec} = 0.00050265$

Ash2 = Astir\_2\*ns\_2 = 100.531

No stirups, ns\_2 = 2.00

h2 = 200.00

-----  
Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471

$c = \text{confinement factor} = 1.03547$   
 $y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.18378198$   
 $su1 = 0.4 * esu1\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 280.5991$   
 with  $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$   
 $y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4 * esu2\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 280.5991$   
 with  $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), \text{TBDY}) = 0.032$   
 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  $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 280.5991$   
 with  $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.07688397$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.07688397$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, \text{TBDY}) = 34.17054$   
 $cc (5A.5, \text{TBDY}) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09875006$   
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.09875006$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied

```

--->
su (4.9) = 0.23357771
Mu = MRc (4.14) = 1.4747E+008
u = su (4.1) = 1.1814054E-005
-----

Calculation of ratio lb/ld
-----

Lap Length: lb/ld = 0.18378198
lb = 300.00
ld = 1632.369
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 = 16.00
Mean strength value of all re-bars: fy = 694.45
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 2.57611
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 = 16.00
-----

Calculation of Mu1-
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 1.1814054E-005
Mu = 1.4747E+008
-----

with full section properties:
b = 400.00
d = 357.00
d' = 43.00
v = 0.0012789
N = 6026.684
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00951404
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00951404
we (5.4c) = 0.02260544
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.24250288
ase1 = 0.24250288
bo_1 = 340.00
ho_1 = 340.00
bi2_1 = 462400.00
ase2 = Max(ase1,ase2) = 0.24250288
bo_2 = 192.00
ho_2 = 192.00
bi2_2 = 147456.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 3.07617
-----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 3.07617
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00392699
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 400.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00050265

```

Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

-----  
psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

-----  
Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015  
shv = 0.00323248  
ftv = 336.7189  
fyv = 280.5991  
suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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

with  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 280.5991$

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 =  $A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$

2 =  $A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

1 =  $A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$

2 =  $A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$\mu_u (4.9) = 0.23357771$

$M_u = M_{Rc} (4.14) = 1.4747E+008$

$u = \mu_u (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

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

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

$u = 1.1814054E-005$

$M_u = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00951404$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00951404$   
 we (5.4c) = 0.02260544  
 ase ((5.4d), TBDY) =  $(\text{ase1} * \text{Aext} + \text{ase2} * \text{Aint}) / \text{Asec} = 0.24250288$   
 $\text{ase1} = 0.24250288$   
 $\text{bo}_1 = 340.00$   
 $\text{ho}_1 = 340.00$   
 $\text{bi2}_1 = 462400.00$   
 $\text{ase2} = \text{Max}(\text{ase1}, \text{ase2}) = 0.24250288$   
 $\text{bo}_2 = 192.00$   
 $\text{ho}_2 = 192.00$   
 $\text{bi2}_2 = 147456.00$   
 $\text{psh, min} * \text{Fywe} = \text{Min}(\text{psh, x} * \text{Fywe}, \text{psh, y} * \text{Fywe}) = 3.07617$

-----  
 $\text{psh, x} * \text{Fywe} = \text{psh1} * \text{Fywe1} + \text{ps2} * \text{Fywe2} = 3.07617$   
 $\text{ps1 (external)} = (\text{Ash1} * \text{h1} / \text{s1}) / \text{Asec} = 0.00392699$   
 $\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$   
 No stirups,  $\text{ns}_1 = 2.00$   
 $\text{h1} = 400.00$   
 $\text{ps2 (internal)} = (\text{Ash2} * \text{h2} / \text{s2}) / \text{Asec} = 0.00050265$   
 $\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$   
 No stirups,  $\text{ns}_2 = 2.00$   
 $\text{h2} = 200.00$

-----  
 $\text{psh, y} * \text{Fywe} = \text{psh1} * \text{Fywe1} + \text{ps2} * \text{Fywe2} = 3.07617$   
 $\text{ps1 (external)} = (\text{Ash1} * \text{h1} / \text{s1}) / \text{Asec} = 0.00392699$   
 $\text{Ash1} = \text{Astir}_1 * \text{ns}_1 = 157.0796$   
 No stirups,  $\text{ns}_1 = 2.00$   
 $\text{h1} = 400.00$   
 $\text{ps2 (internal)} = (\text{Ash2} * \text{h2} / \text{s2}) / \text{Asec} = 0.00050265$   
 $\text{Ash2} = \text{Astir}_2 * \text{ns}_2 = 100.531$   
 No stirups,  $\text{ns}_2 = 2.00$   
 $\text{h2} = 200.00$

-----  
 $\text{Asec} = 160000.00$   
 $\text{s1} = 100.00$   
 $\text{s2} = 250.00$   
 $\text{fywe1} = 694.45$   
 $\text{fywe2} = 694.45$   
 $\text{fce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

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

$\text{lo/lou, min} = \text{lb} / \text{ld} = 0.18378198$

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

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

For calculation of  $\text{esu1\_nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $\text{fsy1} = \text{fs1} / 1.2$ , 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  $\text{fs1} = (\text{fs, jacket} * \text{Asl, ten, jacket} + \text{fs, core} * \text{Asl, ten, core}) / \text{Asl, ten} = 280.5991$

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

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

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

$$l_0/l_{0u,min} = l_b/l_{b,min} = 0.18378198$$

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

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

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

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

$$\text{with } f_{s2} = (f_{s,jacket} \cdot A_{s1,com,jacket} + f_{s,core} \cdot A_{s1,com,core}) / A_{s1,com} = 280.5991$$

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

$$y_v = 0.00101015$$

$$sh_v = 0.00323248$$

$$ft_v = 336.7189$$

$$fy_v = 280.5991$$

$$s_{uv} = 0.00323248$$

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

$$l_0/l_{0u,min} = l_b/l_d = 0.18378198$$

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

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

$$\text{with } f_{sv} = (f_{s,jacket} \cdot A_{s1,mid,jacket} + f_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 280.5991$$

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

$$1 = A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$$

$$2 = A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$$

$$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{s1,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$$

$$2 = A_{s1,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$$

$$v = A_{s1,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u (4.9) = 0.23357771$$

$$\mu_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

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

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

$$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$$
$$n = 16.00$$

Calculation of Mu2-

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

$$u = 1.1814054E-005$$

$$\text{Mu} = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$fy1 = 280.5991$   
 $su1 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/d = 0.18378198$   
 $su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 280.5991$   
 with  $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$   
 $y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 280.5991$   
 with  $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/d = 0.18378198$   
 $suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 280.5991$   
 with  $Es_v = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.07688397$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07688397$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.09875006$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.09875006$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$

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

Lap Length:  $l_b/d = 0.18378198$

$l_b = 300.00$

$d = 1632.369$

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)

$= 1$

$d_b = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$   
-----  
-----  
-----  
-----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$V_{\text{Col}0} = 463630.789$

$k_{nl} = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 4.0970837E-012$

$V_u = 6.7333103E-047$

$d = 0.8 \cdot h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $\text{Col}1 = 1.00$

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$

$b_w = 400.00$   
-----  
-----

Calculation of Shear Strength at edge 2,  $Vr2 = 463630.789$

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

$VCol0 = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$Mu = 4.0970837E-012$

$Vu = 6.7333103E-047$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

$Av = 100530.965$

$fy = 555.56$

$s = 250.00$

$Vs2$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

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

From (11-11), ACI 440:  $Vs + Vf \leq 488465.275$

$bw = 400.00$

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 Secondary Member: Concrete Strength,  $fc = fcm = 33.00$

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

Concrete Elasticity,  $Ec = 26999.444$

Steel Elasticity,  $Es = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $fc = fcm = 33.00$

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

Concrete Elasticity,  $Ec = 26999.444$

Steel Elasticity,  $Es = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_b$  = 300.00  
No FRP Wrapping

-----  
Stepwise Properties  
-----

Bending Moment, M = 1.6113210E-009  
Shear Force, V2 = -6825.705  
Shear Force, V3 = -5.9576024E-013  
Axial Force, F = -6023.953  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st}$  = 1291.195  
-Compression:  $A_{sc}$  = 2001.195  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten}$  = 1291.195  
-Compression:  $A_{sc,com}$  = 1291.195  
-Middle:  $A_{st,mid}$  = 709.9999  
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:  $A_{st,ten,core}$  = 461.8141  
-Compression:  $A_{sc,com,core}$  = 461.8141  
-Middle:  $A_{st,mid,core}$  = 307.8761  
Mean Diameter of Tension Reinforcement,  $D_bL$  = 16.33333

-----  
-----  
New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.00363911$   
 $u = y + p = 0.00363911$

-----  
- Calculation of  $y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00363911$  ((4.29), Biskinis Phd))  
 $M_y = 1.2576E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.7280E+013$   
 $factor = 0.30$   
 $A_g = 160000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 6023.953$   
 $E_c * I_g = E_c_{jacket} * I_g_{jacket} + E_c_{core} * I_g_{core} = 5.7599E+013$

-----  
-----  
Calculation of Yielding Moment  $M_y$   
-----

Calculation of  $y$  and  $M_y$  according to Annex 7 -  
-----

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.2162520E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / d)^{2/3}) = 260.4851$   
 $d = 357.00$   
 $y = 0.30059914$   
 $A = 0.02321789$

B = 0.01307844  
 with pt = 0.00442965  
   pc = 0.00904198  
   pv = 0.00497199  
   N = 6023.953  
   b = 400.00  
   " = 0.12044818  
 y\_comp = 2.0592201E-005  
 with fc = 33.00  
   Ec = 26999.444  
   y = 0.29926824  
   A = 0.02296007  
   B = 0.0129165  
   with Es = 200000.00

-----  
 -----  
 Calculation of ratio  $l_b/l_d$

Lap Length:  $l_d/l_{d,min} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

-----  
 - 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  $V_y E / V_{CoI} E = 0.21205453$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$

jacket:  $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$

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

$h_1 = 400.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

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

$h_2 = 200.00$

$s_2 = 250.00$

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.

$N_{UD} = 6023.953$

$A_g = 160000.00$

$f_c E = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section\_area = 33.00$

$f_y E = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 555.56$

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

555.56

$\rho_l = \text{Area\_Tot\_Long\_Rein}/(b*d) = 0.02305595$

$b = 400.00$

$d = 357.00$

$f_{cE} = 33.00$

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

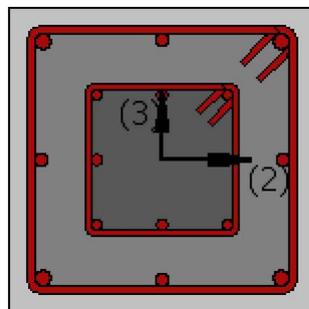
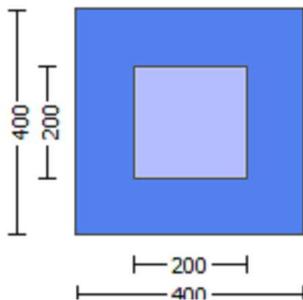
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 1.6113210E-009$

Shear Force,  $V_a = -5.9576024E-013$

EDGE -B-

Bending Moment,  $M_b = 1.7638548E-010$

Shear Force,  $V_b = 5.9576024E-013$

BOTH EDGES

Axial Force,  $F = -6023.953$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 1291.195$

-Compression:  $A_{sc} = 2001.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.33333$

-----  
New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 * V_n = 411960.604$

$V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI} = 411960.604$

$V_{CoI} = 411960.604$

$k_n = 1.00$

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).

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

Mean concrete strength:  $f'_c = (f'_c\_jacket * Area\_jacket + f'_c\_core * Area\_core) / Area\_section = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 1.6113210E-009$

$V_u = 5.9576024E-013$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 6023.953$   
 $A_g = 160000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$   
 where:  
 $V_{s1} = 251327.412$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 425154.451$   
 $b_w = 400.00$

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

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

From analysis, chord rotation  $\theta = 2.3685841E-020$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00363911$  ((4.29), Biskinis Phd)  
 $M_y = 1.2576E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.7280E+013$   
 $factor = 0.30$   
 $A_g = 160000.00$   
 Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area_{jacket} + f'_{c\_core} \cdot Area_{core}) / Area_{section} = 33.00$   
 $N = 6023.953$   
 $E_c \cdot I_g = E_{c\_jacket} \cdot I_{g\_jacket} + E_{c\_core} \cdot I_{g\_core} = 5.7599E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta_u / y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 5.2162520E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/d)^{2/3}) = 260.4851$   
 $d = 357.00$   
 $y = 0.30059914$   
 $A = 0.02321789$   
 $B = 0.01307844$   
 with  $pt = 0.00904198$   
 $pc = 0.00904198$   
 $pv = 0.00497199$   
 $N = 6023.953$   
 $b = 400.00$   
 $\alpha = 0.12044818$   
 $y_{comp} = 2.0592201E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.29926824$   
 $A = 0.02296007$   
 $B = 0.0129165$

with  $E_s = 200000.00$

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_d/l_{d,min} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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)

$= 1$

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

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

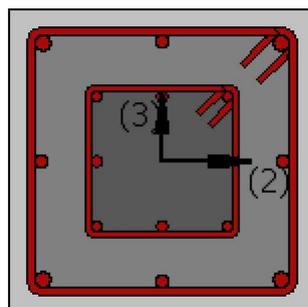
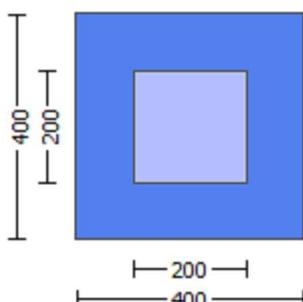
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.03547

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -1.0996693E-030$

EDGE -B-

Shear Force,  $V_b = 1.0996693E-030$

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression:  $A_{sl,c} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21205453$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.4747E+008$

$\mu_{u1+} = 1.4747E+008$ , 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

$\mu_{u1-} = 1.4747E+008$ , 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

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.4747E+008$

$\mu_{u2+} = 1.4747E+008$ , 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

$\mu_{u2-} = 1.4747E+008$ , 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:

$\phi_u = 1.1814054E-005$

$\mu_u = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$

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

From (5.4b), TBDY:  $\phi_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i21} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i22} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

-----  
 $p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$

No stirups,  $n_{s, 1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$

No stirups,  $n_{s, 2} = 2.00$

$h_2 = 200.00$

-----  
 $p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$

No stirups,  $n_{s, 1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$

No stirups,  $n_{s, 2} = 2.00$

$h_2 = 200.00$

-----  
 $A_{sec} = 160000.00$

$s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $y_1 = 0.00101015$   
 $sh_1 = 0.00323248$   
 $ft_1 = 336.7189$   
 $fy_1 = 280.5991$   
 $su_1 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.18378198$   
 $su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{1\_nominal} = 0.08$ ,  
 For calculation of  $esu_{1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$   
 with  $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.18378198$   
 $su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,  
 For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 280.5991$   
 with  $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.07688397$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.07688397$   
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.09875006$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.23357771$$

$$M_u = M_{Rc}(4.14) = 1.4747E+008$$

$$u = s_u(4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

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

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

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

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

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e(5.4c) = 0.02260544$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i2,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i2,2} = 147456.00$$

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.07617$$

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y1 = 0.00101015

sh1 = 0.00323248

ft1 = 336.7189

fy1 = 280.5991

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

----

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

----

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/ld

-----  
Lap Length: lb/ld = 0.18378198

lb = 300.00

ld = 1632.369

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 = 16.00

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

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 33.00, but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.57611

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 = 16.00

-----  
Calculation of Mu2+

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

u = 1.1814054E-005

Mu = 1.4747E+008

-----  
with full section properties:

b = 400.00

$d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00951404$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00951404$   
 $w_e (5.4c) = 0.02260544$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$   
 $ase1 = 0.24250288$   
 $bo_1 = 340.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 462400.00$   
 $ase2 = Max(ase1, ase2) = 0.24250288$   
 $bo_2 = 192.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 147456.00$   
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$A_{sec} = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = confinement\ factor = 1.03547$   
 $y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lo_{u,min} = lb/d = 0.18378198$   
 $su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 280.5991$   
 with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$   
 $y2 = 0.00101015$   
 $sh2 = 0.00323248$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

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

$$lo/lou,min = lb/lb,min = 0.18378198$$

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

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.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 280.5991$$

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

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

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

$$lo/lou,min = lb/ld = 0.18378198$$

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

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.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 280.5991$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07688397$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.07688397$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.09875006$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09875006$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$su (4.9) = 0.23357771$$

$$Mu = MRc (4.14) = 1.4747E+008$$

$$u = su (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio lb/ld

-----  
Lap Length: lb/ld = 0.18378198

$$lb = 300.00$$

$$ld = 1632.369$$

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)

$$= 1$$

$$db = 16.00$$

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

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 33.00, but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.57611$   
 $Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$   
 where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$   
 $n = 16.00$

-----  
 Calculation of  $\mu_2$ -  
 -----

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

$\mu = 1.1814054E-005$   
 $\mu = 1.4747E+008$

-----  
 with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_s) = 0.00951404$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\mu_c = 0.00951404$   
 $\mu_s (5.4c) = 0.02260544$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$   
 $ase1 = 0.24250288$   
 $bo_1 = 340.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 462400.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$   
 $bo_2 = 192.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 147456.00$   
 $psh_{\text{min}} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$   
 $ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 3.07617$   
 $ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $A_{sec} = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$

$f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $y_1 = 0.00101015$   
 $sh_1 = 0.00323248$   
 $ft_1 = 336.7189$   
 $fy_1 = 280.5991$   
 $su_1 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, \min = lb/ld = 0.18378198$   
 $su_1 = 0.4 * esu_1 \text{ nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, \text{ten}, \text{jacket} + fs_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 280.5991$   
 with  $Es_1 = (Es_{jacket} * Asl, \text{ten}, \text{jacket} + Es_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, \min = lb/lb, \min = 0.18378198$   
 $su_2 = 0.4 * esu_2 \text{ nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl, \text{com}, \text{jacket} + fs_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 280.5991$   
 with  $Es_2 = (Es_{jacket} * Asl, \text{com}, \text{jacket} + Es_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, \min = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv \text{ nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl, \text{mid}, \text{jacket} + fs_{mid} * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 280.5991$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid}, \text{jacket} + Es_{mid} * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

--->  
su (4.9) = 0.23357771  
Mu = MRc (4.14) = 1.4747E+008  
u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Lap Length: lb/l<sub>d</sub> = 0.18378198

lb = 300.00

l<sub>d</sub> = 1632.369

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 = 16.00

Mean strength value of all re-bars: f<sub>y</sub> = 694.45

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> = 33.00, 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> = 2.57611

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 = 16.00

-----  
Calculation of Shear Strength V<sub>r</sub> = Min(V<sub>r1</sub>,V<sub>r2</sub>) = 463630.789

-----  
Calculation of Shear Strength at edge 1, V<sub>r1</sub> = 463630.789

V<sub>r1</sub> = V<sub>Col</sub> ((10.3), ASCE 41-17) = knl\*V<sub>Col0</sub>

V<sub>Col0</sub> = 463630.789

knl = 1 (zero step-static loading)

-----  
NOTE: In expression (10-3) 'V<sub>s</sub> = A<sub>v</sub>\*f<sub>y</sub>\*d/s' is replaced by 'V<sub>s</sub>+ f\*V<sub>f</sub>'  
where V<sub>f</sub> 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> = 33.00, but f<sub>c</sub>'<sup>0.5</sup> <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/V<sub>d</sub> = 2.00

Mu = 9.7987490E-012

Vu = 1.0996693E-030

d = 0.8\*h = 320.00

Nu = 6026.684

Ag = 160000.00

From (11.5.4.8), ACI 318-14: V<sub>s</sub> = V<sub>s1</sub> + V<sub>s2</sub> = 279254.914

where:

V<sub>s1</sub> = 279254.914 is calculated for jacket, with:

d = 320.00

A<sub>v</sub> = 157079.633

f<sub>y</sub> = 555.56

s = 100.00

V<sub>s1</sub> is multiplied by Col1 = 1.00

s/d = 0.3125

V<sub>s2</sub> = 0.00 is calculated for core, with:

d = 160.00

A<sub>v</sub> = 100530.965

f<sub>y</sub> = 555.56

s = 250.00

V<sub>s2</sub> is multiplied by Col2 = 0.00

s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
Calculation of Shear Strength at edge 2, Vr2 = 463630.789  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 463630.789  
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 = 33.00, but fc'^0.5 <= 8.3  
MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 9.7987490E-012  
Vu = 1.0996693E-030  
d = 0.8\*h = 320.00  
Nu = 6026.684  
Ag = 160000.00  
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914  
where:  
Vs1 = 279254.914 is calculated for jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.3125  
Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
Existing Column  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
#####  
External Height,  $H = 400.00$   
External Width,  $W = 400.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 200.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.03547  
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = 300.00$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 6.7333103E-047$   
EDGE -B-  
Shear Force,  $V_b = -6.7333103E-047$   
BOTH EDGES  
Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1291.195$   
-Compression:  $A_{sc,com} = 1291.195$   
-Middle:  $A_{sc,mid} = 709.9999$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with  
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.4747E+008$   
 $\mu_{u1+} = 1.4747E+008$ , 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  
 $\mu_{u1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.4747E+008$   
 $\mu_{u2+} = 1.4747E+008$ , 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  
 $\mu_{u2-} = 1.4747E+008$ , 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:

$$u = 1.1814054E-005$$

$$\mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00951404$$

$$w_e(5.4c) = 0.022260544$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

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

$$l_o / l_{o, \min} = l_b / d = 0.18378198$$

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

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

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  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 280.5991$

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

$y_2 = 0.00101015$

$sh_2 = 0.00323248$

$ft_2 = 336.7189$

$fy_2 = 280.5991$

$su_2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 0.18378198$

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

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  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 280.5991$

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

$y_v = 0.00101015$

$sh_v = 0.00323248$

$ft_v = 336.7189$

$fy_v = 280.5991$

$su_v = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 0.18378198$

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

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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 280.5991$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.07688397$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.07688397$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.09875006$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09875006$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_s, y_2$  - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.23357771$

$Mu = MRc (4.14) = 1.4747E+008$

$u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$\rho = 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $f_y = 694.45$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

-----  
 -----  
 -----  
 Calculation of  $\mu_1$ -  
 -----

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 1.1814054E-005$   
 $\mu_1 = 1.4747E+008$

-----  
 with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\alpha_1$  (5A.5, TBDY) = 0.002  
 Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} \cdot \text{Max}(\mu_c, \mu_{cc}) = 0.00951404$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\mu_c = 0.00951404$   
 $w_e$  (5.4c) = 0.02260544  
 $\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} \cdot A_{ext} + \alpha_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$   
 $\alpha_{se1} = 0.24250288$   
 $b_{o1} = 340.00$   
 $h_{o1} = 340.00$   
 $b_{i2} = 462400.00$   
 $\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.24250288$   
 $b_{o2} = 192.00$   
 $h_{o2} = 192.00$   
 $b_{i2} = 147456.00$   
 $p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.07617$

-----  
 $p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$   
 $p_{s1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir_1} \cdot n_{s1} = 157.0796$   
 No stirups,  $n_{s1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir_2} \cdot n_{s2} = 100.531$   
 No stirups,  $n_{s2} = 2.00$   
 $h_2 = 200.00$

-----  
 $p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$   
 $p_{s1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir_1} \cdot n_{s1} = 157.0796$   
 No stirups,  $n_{s1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir_2} \cdot n_{s2} = 100.531$   
 No stirups,  $n_{s2} = 2.00$   
 $h_2 = 200.00$

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y1 = 0.00101015

sh1 = 0.00323248

ft1 = 336.7189

fy1 = 280.5991

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = (fsjacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = (fsjacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 =  $Asl_{ten}/(b*d)*(fs1/fc) = 0.09875006$

2 =  $Asl_{com}/(b*d)*(fs2/fc) = 0.09875006$

v =  $Asl_{mid}/(b*d)*(fsv/fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/l<sub>d</sub>

Lap Length: lb/l<sub>d</sub> = 0.18378198

lb = 300.00

l<sub>d</sub> = 1632.369

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 = 16.00

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

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.57611

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 = 16.00

-----  
Calculation of Mu2+

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

u = 1.1814054E-005

Mu = 1.4747E+008

-----  
with full section properties:

b = 400.00

d = 357.00

d' = 43.00

v = 0.0012789

N = 6026.684

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00951404

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

From (5.4b), TBDY: cu = 0.00951404

we (5.4c) = 0.02260544

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.24250288

ase1 = 0.24250288

bo\_1 = 340.00

ho\_1 = 340.00

bi2\_1 = 462400.00

ase2 = Max(ase1,ase2) = 0.24250288

bo\_2 = 192.00

ho\_2 = 192.00

bi2\_2 = 147456.00

$$psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 3.07617$$

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 200.00$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 3.07617$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$sh1 = 0.00323248$$

$$ft1 = 336.7189$$

$$fy1 = 280.5991$$

$$su1 = 0.00323248$$

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

$$lo/lou_{min} = lb/ld = 0.18378198$$

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

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

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

$$\text{with } fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 280.5991$$

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

$$y2 = 0.00101015$$

$$sh2 = 0.00323248$$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

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

$$lo/lou_{min} = lb/lb_{min} = 0.18378198$$

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

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

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

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 280.5991$$

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

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.18378198$$

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

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.

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

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 280.5991$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.07688397$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.07688397$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.09875006$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09875006$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$M_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

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

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of  $M_u2$ -  
-----

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

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$
  
-----

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear\_factor} * \text{Max}(\phi, \phi_c) = 0.00951404$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00951404$$

$$\phi_w (5.4c) = 0.02260544$$

$$\phi_{se} ((5.4d), \text{TB DY}) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$\phi_{se1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i21} = 462400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i22} = 147456.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.07617$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.07617$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.07617$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$F_{ywe1} = 694.45$$

$$F_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_c = 0.00235471$$

$$\phi_c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

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

$$l_o / l_{ou, \min} = l_b / d = 0.18378198$$

$$su_1 = 0.4 * \phi_{su1, \text{nominal}} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su1, \text{nominal}} = 0.08,$$

For calculation of  $\phi_{su1, \text{nominal}}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_{s1} / 1.2$ , from table 5.1, TB DY.

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

$$\text{with } f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$$

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

$y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/lb_{min} = 0.18378198$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 280.5991$   
 with  $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 280.5991$   
 with  $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05430052$

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

--->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/ld$

-----  
 Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
-----  
-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$$V_{\text{Col}0} = 463630.789$$

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

-----  
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).

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

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00, \text{ but } f_c'^{0.5} \leq 8.3$$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8 * h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

$V_{s1}$  is multiplied by  $\text{Col}1 = 1.00$

$$s/d = 0.3125$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 488465.275$$

$$b_w = 400.00$$

-----  
-----  
-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 463630.789$

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

$$V_{\text{Col}0} = 463630.789$$

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

-----  
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).

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

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00, \text{ but } f_c'^{0.5} \leq 8.3$$

MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

Vu = 6.7333103E-047  
d = 0.8\*h = 320.00  
Nu = 6026.684  
Ag = 160000.00  
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914  
where:  
Vs1 = 279254.914 is calculated for jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.3125  
Vs2 = 0.00 is calculated for core, with:  
d = 160.00  
Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
External Height, H = 400.00  
External Width, W = 400.00  
Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length lb = 300.00  
No FRP Wrapping

## Stepwise Properties

Bending Moment,  $M = -2.0483E+007$

Shear Force,  $V2 = -6825.705$

Shear Force,  $V3 = -5.9576024E-013$

Axial Force,  $F = -6023.953$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 1291.195$

-Compression:  $As_c = 2001.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{,ten} = 1291.195$

-Compression:  $As_{,com} = 1291.195$

-Middle:  $As_{,mid} = 709.9999$

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:  $As_{,ten,core} = 461.8141$

-Compression:  $As_{,com,core} = 461.8141$

-Middle:  $As_{,mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = 1.0^*$   $u = 0.00728036$   
 $u = y + p = 0.00728036$

- Calculation of  $y$  -

$y = (My * Ls / 3) / Eleff = 0.00728036$  ((4.29), Biskinis Phd))

$My = 1.2576E+008$

$Ls = M/V$  (with  $Ls > 0.1 * L$  and  $Ls < 2 * L$ ) = 3000.884

From table 10.5, ASCE 41\_17:  $Eleff = factor * Ec * Ig = 1.7280E+013$

factor = 0.30

$Ag = 160000.00$

Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 6023.953$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 5.7599E+013$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

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

$y_{ten} = 5.2162520E-006$

with ((10.1), ASCE 41-17)  $fy = \text{Min}(fy, 1.25 * fy * (lb/d)^{2/3}) = 260.4851$

$d = 357.00$

$y = 0.30059914$

$A = 0.02321789$

$B = 0.01307844$

with  $pt = 0.00442965$

$pc = 0.00904198$

$p_v = 0.00497199$

$N = 6023.953$

$b = 400.00$

$" = 0.12044818$

$y_{comp} = 2.0592201E-005$

with  $fc = 33.00$

$Ec = 26999.444$

$y = 0.29926824$

$A = 0.02296007$

$B = 0.0129165$

with  $E_s = 200000.00$

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_d/l_{d,min} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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)

$= 1$

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

- 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  $V_y E / V_{col} E = 0.21205453$

$d = d_{external} = 357.00$

$s = s_{external} = 0.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$

jacket:  $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$

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

$h_1 = 400.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

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

$h_2 = 200.00$

$s_2 = 250.00$

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.

$N_{UD} = 6023.953$

$A_g = 160000.00$

$f'_{cE} = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / section\_area = 33.00$

$f_{yIE} = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 555.56$

$f_{yTE} = (f_{y,ext\_Trans\_Reinf} \cdot Area_{ext\_Trans\_Reinf} + f_{y,int\_Trans\_Reinf} \cdot Area_{int\_Trans\_Reinf}) / Area_{Tot\_Trans\_Rein} = 555.56$

$\rho_l = Area_{Tot\_Long\_Rein} / (b \cdot d) = 0.02305595$

$b = 400.00$

$d = 357.00$

$f'_{cE} = 33.00$

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

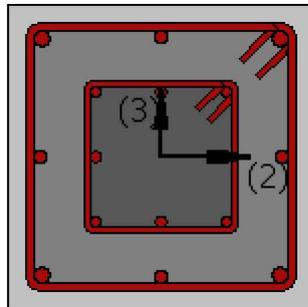
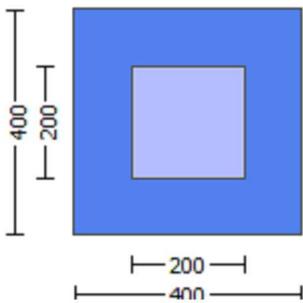
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

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

Existing Column

New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
 #####  
 External Height,  $H = 400.00$   
 External Width,  $W = 400.00$   
 Internal Height,  $H = 200.00$   
 Internal Width,  $W = 200.00$   
 Cover Thickness,  $c = 25.00$   
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
 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,  $M_a = -2.0483E+007$   
 Shear Force,  $V_a = -6825.705$   
 EDGE -B-  
 Bending Moment,  $M_b = -0.01979425$   
 Shear Force,  $V_b = 6825.705$   
 BOTH EDGES  
 Axial Force,  $F = -6023.953$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{st} = 0.00$   
 -Compression:  $A_{sc} = 3292.389$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten} = 1291.195$   
 -Compression:  $A_{st,com} = 1291.195$   
 -Middle:  $A_{st,mid} = 709.9999$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.33333$

-----  
 -----  
 New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 * V_n = 411960.604$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI0} = 411960.604$   
 $V_{CoI} = 411960.604$   
 $k_n = 1.00$   
 displacement\_ductility\_demand = 0.24427809

-----  
 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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 25.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M / Vd = 2.00$   
 $M_u = 0.01979425$   
 $V_u = 6825.705$   
 $d = 0.8 * h = 320.00$   
 $N_u = 6023.953$   
 $A_g = 160000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$   
 where:  
 $V_{s1} = 251327.412$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $CoI1 = 1.00$   
 $s/d = 0.3125$

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 500.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 425154.451

bw = 400.00

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 = 0.00017779

y = (My\* $L_s/3$ )/Eleff = 0.00072782 ((4.29),Biskinis Phd))

My = 1.2576E+008

Ls = M/V (with  $L_s > 0.1*L$  and  $L_s < 2*L$ ) = 300.00

From table 10.5, ASCE 41\_17: Eleff = factor\*Ec\*Ig = 1.7280E+013

factor = 0.30

Ag = 160000.00

Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

N = 6023.953

Ec\*Ig = Ec\_jacket\*Ig\_jacket + Ec\_core\*Ig\_core = 5.7599E+013

Calculation of Yielding Moment My

Calculation of  $\delta / y$  and My according to Annex 7 -

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

$y_{ten} = 5.2162520E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/d)^{2/3}) = 260.4851$

d = 357.00

y = 0.30059914

A = 0.02321789

B = 0.01307844

with pt = 0.00904198

pc = 0.00904198

pv = 0.00497199

N = 6023.953

b = 400.00

" = 0.12044818

$y_{comp} = 2.0592201E-005$

with  $fc = 33.00$

Ec = 26999.444

y = 0.29926824

A = 0.02296007

B = 0.0129165

with Es = 200000.00

Calculation of ratio  $l_b/d$

Lap Length:  $l_d/l_{d,min} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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

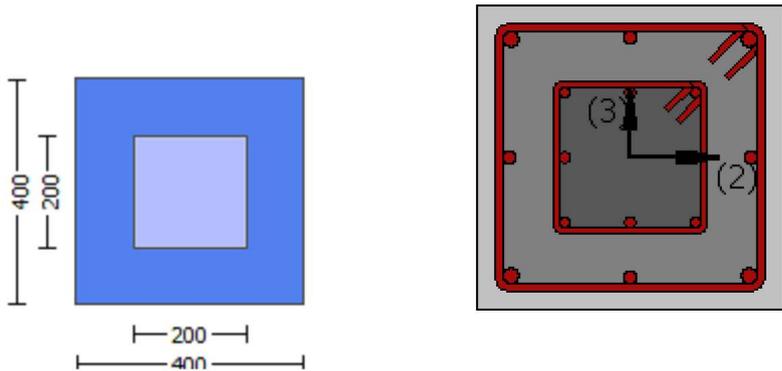
db = 16.00

Mean strength value of all re-bars:  $f_y = 555.56$   
 Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis  
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$   
 $n = 16.00$

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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
External Height,  $H = 400.00$ 
External Width,  $W = 400.00$ 
Internal Height,  $H = 200.00$ 
Internal Width,  $W = 200.00$ 
Cover Thickness,  $c = 25.00$ 
Mean Confinement Factor overall section = 1.03547
Element Length,  $L = 3000.00$ 
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length  $l_o = 300.00$ 
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -1.0996693E-030$ 
EDGE -B-
Shear Force,  $V_b = 1.0996693E-030$ 
BOTH EDGES
Axial Force,  $F = -6026.684$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{sl} = 0.00$ 
-Compression:  $A_{sc} = 3292.389$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl,ten} = 1291.195$ 
-Compression:  $A_{sl,com} = 1291.195$ 
-Middle:  $A_{sl,mid} = 709.9999$ 
-----
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$ 
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4747E+008$ 
 $Mu_{1+} = 1.4747E+008$ , 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
 $Mu_{1-} = 1.4747E+008$ , 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
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4747E+008$ 
 $Mu_{2+} = 1.4747E+008$ , 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
 $Mu_{2-} = 1.4747E+008$ , 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:

$$\mu = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_o) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

-----  
$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

-----  
$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

-----  
$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

Calculation of  $\mu_1$ -

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

$\mu = 1.1814054E-005$

$\mu_1 = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u = \text{shear\_factor} \cdot \text{Max}(\phi_u, \phi_c) = 0.00951404$

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

From (5.4b), TBDY:  $\phi_u = 0.00951404$

$\phi_{ue}$  (5.4c) = 0.02260544

$\phi_{ui}$  ((5.4d), TBDY) =  $(\phi_{e1} \cdot A_{ext} + \phi_{e2} \cdot A_{int}) / A_{sec} = 0.24250288$

$\phi_{e1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2} = 462400.00$

$\phi_{e2} = \text{Max}(\phi_{e1}, \phi_{e2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2} = 147456.00$

$\phi_{sh, \min} \cdot F_{ywe} = \text{Min}(\phi_{sh, x} \cdot F_{ywe}, \phi_{sh, y} \cdot F_{ywe}) = 3.07617$

$\phi_{sh, x} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.07617$

$\phi_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$h_1 = 400.00$

$\phi_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s2} = 100.531$

No stirrups,  $n_{s2} = 2.00$

$h_2 = 200.00$

$\phi_{sh, y} \cdot F_{ywe} = \phi_{sh1} \cdot F_{ywe1} + \phi_{sh2} \cdot F_{ywe2} = 3.07617$

$\phi_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s1} = 157.0796$

No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00050265$   
 $Ash2 = Astir\_2 \cdot ns_2 = 100.531$   
No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $Asec = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

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

$lo/lou, \min = lb/ld = 0.18378198$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((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  $fs1 = (fs\_jacket \cdot Asl, \text{ten}, \text{jacket} + fs\_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 280.5991$

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

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

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

$lo/lou, \min = lb/lb, \min = 0.18378198$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((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  $fs2 = (fs\_jacket \cdot Asl, \text{com}, \text{jacket} + fs\_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 280.5991$

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

$yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$

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

$lo/lou, \min = lb/ld = 0.18378198$   
 $suv = 0.4 \cdot esuv\_nominal$  ((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  $fsv = (fs\_jacket \cdot Asl, \text{mid}, \text{jacket} + fs\_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 280.5991$

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

$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.07688397$   
 $2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fce) = 0.07688397$   
 $v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fce) = 0.04227683$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(fs1/fc) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(fs2/fc) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$M_u = MR_c (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of  $M_u2+$

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

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e (5.4c) = 0.02260544$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $su_v = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.18378198$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fs_yv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_yv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 280.5991$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 34.17054$   
 $cc(5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su(4.9) = 0.23357771$   
 $Mu = MRc(4.14) = 1.4747E+008$   
 $u = su(4.1) = 1.1814054E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Lap Length:  $l_b/l_d = 0.18378198$   
 $l_b = 300.00$   
 $l_d = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

-----  
 Calculation of  $Mu_2$ -  
 -----

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

$$u = 1.1814054E-005$$

$$\mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00951404$$

$$\phi_{we} \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_{cc} = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

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

$$l_o / l_{ou, \min} = l_b / d = 0.18378198$$

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl,ten,jacket + fs\_core \cdot Asl,ten,core) / Asl,ten = 280.5991$

with  $Es1 = (Es\_jacket \cdot Asl,ten,jacket + Es\_core \cdot Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.00101015$

$sh2 = 0.00323248$

$ft2 = 336.7189$

$fy2 = 280.5991$

$su2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou,min = lb/lb,min = 0.18378198$

$su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$

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  $fs2 = (fs\_jacket \cdot Asl,com,jacket + fs\_core \cdot Asl,com,core) / Asl,com = 280.5991$

with  $Es2 = (Es\_jacket \cdot Asl,com,jacket + Es\_core \cdot Asl,com,core) / Asl,com = 200000.00$

$yv = 0.00101015$

$shv = 0.00323248$

$ftv = 336.7189$

$fyv = 280.5991$

$su2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou,min = lb/ld = 0.18378198$

$su2 = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$

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  $fsv = (fs\_jacket \cdot Asl,mid,jacket + fs\_mid \cdot Asl,mid,core) / Asl,mid = 280.5991$

with  $Es2 = (Es\_jacket \cdot Asl,mid,jacket + Es\_mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07688397$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.07688397$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.09875006$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.09875006$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$su (4.9) = 0.23357771$

$Mu = MRc (4.14) = 1.4747E+008$

$u = su (4.1) = 1.1814054E-005$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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)

$$= 1$$

$db = 16.00$   
Mean strength value of all re-bars:  $f_y = 694.45$   
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$V_{\text{Col}0} = 463630.789$

$k_{nl} = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$M_u = 9.7987490E-012$

$V_u = 1.0996693E-030$

$d = 0.8 \cdot h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$

$bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 463630.789$

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

$V_{\text{Col}0} = 463630.789$

$k_{nl} = 1$  (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:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 9.7987490E-012$   
 $V_u = 1.0996693E-030$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 6026.684$   
 $A_g = 160000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
 where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$   
 $b_w = 400.00$

-----  
 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Jacket  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 Existing Column  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 #####  
 External Height,  $H = 400.00$   
 External Width,  $W = 400.00$

Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.03547  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length lo = 300.00  
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force, Va = 6.7333103E-047  
EDGE -B-  
Shear Force, Vb = -6.7333103E-047  
BOTH EDGES  
Axial Force, F = -6026.684  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: Aslt = 0.00  
-Compression: Aslc = 3292.389  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten = 1291.195  
-Compression: Asl,com = 1291.195  
-Middle: Asl,mid = 709.9999  
-----  
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.4747E+008$   
 $Mu_{1+} = 1.4747E+008$ , 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  
 $Mu_{1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.4747E+008$   
 $Mu_{2+} = 1.4747E+008$ , 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  
 $Mu_{2-} = 1.4747E+008$ , 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:  
 $\phi_u = 1.1814054E-005$   
 $Mu = 1.4747E+008$   
-----

with full section properties:

b = 400.00  
d = 357.00  
d' = 43.00  
v = 0.0012789  
N = 6026.684  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu} , \phi_{cc}) = 0.00951404$

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

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o\_1} = 340.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o\_2} = 192.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

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

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

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

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

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

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$

$c$  = confinement factor = 1.03547

$y_1 = 0.00101015$

$sh_1 = 0.00323248$

$ft_1 = 336.7189$

$fy_1 = 280.5991$

$su_1 = 0.00323248$

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

$l_o / l_{o, \min} = l_b / l_d = 0.18378198$

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$

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

$y_2 = 0.00101015$

$sh_2 = 0.00323248$

$ft_2 = 336.7189$

$fy_2 = 280.5991$

$su_2 = 0.00323248$

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

$l_o / l_{o, \min} = l_b / l_{b, \min} = 0.18378198$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs\_jacket * Asl\_com\_jacket + fs\_core * Asl\_com\_core) / Asl\_com = 280.5991$   
 with  $Es_2 = (Es\_jacket * Asl\_com\_jacket + Es\_core * Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 280.5991$   
 with  $Es_v = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} <= 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.57611$   
 $Atr = Min(Atr\_x, Atr\_y) = 257.6106$   
 where  $Atr\_x, Atr\_y$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = Max(s\_external, s\_internal) = 250.00$

$$n = 16.00$$

Calculation of Mu1-

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

$$u = 1.1814054E-005$$

$$\text{Mu} = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$l_b = 300.00$

$d = 1632.369$

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)

$= 1$

$d_b = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

Calculation of  $\mu_{2+}$

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

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00951404$

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

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2,1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2,2} = 147456.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.07617$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$p_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} \cdot n_{s, 1} = 157.0796$

No stirrups,  $n_{s, 1} = 2.00$

$h_1 = 400.00$

$p_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} \cdot n_{s, 2} = 100.531$

No stirrups,  $n_{s, 2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$sh1 = 0.00323248$$

$$ft1 = 336.7189$$

$$fy1 = 280.5991$$

$$su1 = 0.00323248$$

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

$$lo/lou, \text{min} = lb/ld = 0.18378198$$

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

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

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.

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

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$$

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

$$y2 = 0.00101015$$

$$sh2 = 0.00323248$$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.18378198$$

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

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

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.

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

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 280.5991$$

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

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

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

$$lo/lou, \text{min} = lb/ld = 0.18378198$$

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

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

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.

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

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$$

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.07688397$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07688397$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$\mu_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

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

-----  
Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

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

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of  $\mu_u$

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

$$u = 1.1814054E-005$$

$$\mu_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e (5.4c) = 0.02260544$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

ase1 = 0.24250288  
bo\_1 = 340.00  
ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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  $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 280.5991$

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

$yv = 0.00101015$

$shv = 0.00323248$

$ftv = 336.7189$

$fyv = 280.5991$

$suv = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou,min = lb/d = 0.18378198$

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

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  $fsv = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 280.5991$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs1 / fc) = 0.07688397$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs2 / fc) = 0.07688397$

$v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs1 / fc) = 0.09875006$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs2 / fc) = 0.09875006$

$v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23357771$

$Mu = MRc (4.14) = 1.4747E+008$

$u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/d$

Lap Length:  $lb/d = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 2.57611$

$Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$

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

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

$n = 16.00$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$V_{Col0} = 463630.789$

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

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

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

$= 1$  (normal-weight concrete)

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

$M / Vd = 2.00$

$\mu_u = 4.0970837E-012$

$\nu_u = 6.7333103E-047$

$d = 0.8 * h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$

$bw = 400.00$   
-----

Calculation of Shear Strength at edge 2,  $V_{r2} = 463630.789$

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

$V_{Col0} = 463630.789$

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

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

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

$= 1$  (normal-weight concrete)

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

$M / Vd = 2.00$

$\mu_u = 4.0970837E-012$

$\nu_u = 6.7333103E-047$

$d = 0.8 * h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 488465.275

bw = 400.00

-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00

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

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

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

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

External Height, H = 400.00

External Width, W = 400.00

Internal Height, H = 200.00

Internal Width, W = 200.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length lb = 300.00

No FRP Wrapping

-----  
Stepwise Properties

Bending Moment, M = 1.7638548E-010

Shear Force, V2 = 6825.705

Shear Force, V3 = 5.9576024E-013

Axial Force, F = -6023.953

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Asc = 3292.389

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1291.195

-Compression: Asl,com = 1291.195

-Middle: Asl,mid = 709.9999

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:  $Asl_{ten,core} = 461.8141$

-Compression:  $Asl_{com,core} = 461.8141$

-Middle:  $Asl_{mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.00363911$

$u = y + p = 0.00363911$

- Calculation of  $y$  -

$y = (My * Ls / 3) / Eleff = 0.00363911$  ((4.29), Biskinis Phd))

$My = 1.2576E+008$

$Ls = M/V$  (with  $Ls > 0.1 * L$  and  $Ls < 2 * L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $Eleff = factor * Ec * Ig = 1.7280E+013$

factor = 0.30

$Ag = 160000.00$

Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 6023.953$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 5.7599E+013$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

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

$y_{ten} = 5.2162520E-006$

with ((10.1), ASCE 41-17)  $fy = \text{Min}(fy, 1.25 * fy * (lb/d)^{2/3}) = 260.4851$

$d = 357.00$

$y = 0.30059914$

$A = 0.02321789$

$B = 0.01307844$

with  $pt = 0.00442965$

$pc = 0.00904198$

$pv = 0.00497199$

$N = 6023.953$

$b = 400.00$

$" = 0.12044818$

$y_{comp} = 2.0592201E-005$

with  $fc = 33.00$

$Ec = 26999.444$

$y = 0.29926824$

$A = 0.02296007$

$B = 0.0129165$

with  $Es = 200000.00$

Calculation of ratio  $lb/d$

Lap Length:  $ld/d, \text{min} = 0.22972747$

$lb = 300.00$

$ld = 1305.895$

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

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

= 1

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$   
 Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis  
 $s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$   
 $n = 16.00$

-----  
 - 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  $V_y E / V_{CoI} E = 0.21205453$

$d = d_{\text{external}} = 357.00$

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

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$

jacket:  $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$

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

$h_1 = 400.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$

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

$h_2 = 200.00$

$s_2 = 250.00$

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.

$N_{UD} = 6023.953$

$A_g = 160000.00$

$f_{cE} = (f_{c'}_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_{c'}_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 33.00$

$f_{yIE} = (f_{y_{\text{ext\_Long\_Reinf}}} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 555.56$

$f_{yTE} = (f_{y_{\text{ext\_Trans\_Reinf}}} \cdot \text{Area}_{\text{ext\_Trans\_Reinf}} + f_{y_{\text{int\_Trans\_Reinf}}} \cdot \text{Area}_{\text{int\_Trans\_Reinf}}) / \text{Area}_{\text{Tot\_Trans\_Rein}} = 555.56$

$\rho_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.02305595$

$b = 400.00$

$d = 357.00$

$f_{cE} = 33.00$

-----  
 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

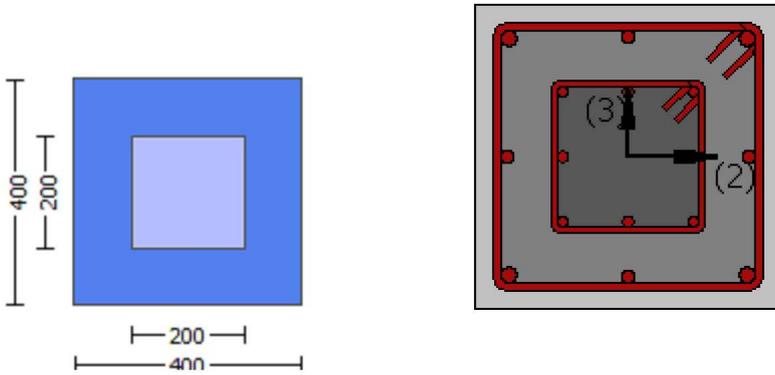
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

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, = 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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_o = l_b = 300.00$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

EDGE -A-  
Bending Moment,  $M_a = 1.6113210E-009$   
Shear Force,  $V_a = -5.9576024E-013$   
EDGE -B-  
Bending Moment,  $M_b = 1.7638548E-010$   
Shear Force,  $V_b = 5.9576024E-013$   
BOTH EDGES  
Axial Force,  $F = -6023.953$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{s,ten} = 1291.195$   
-Compression:  $A_{s,com} = 1291.195$   
-Middle:  $A_{s,mid} = 709.9999$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.33333$

-----  
New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 * V_n = 411960.604$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n * V_{CoI} = 411960.604$   
 $V_{CoI} = 411960.604$   
 $k_n = 1.00$   
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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 25.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)  
 $M / Vd = 2.00$   
 $M_u = 1.7638548E-010$   
 $V_u = 5.9576024E-013$   
 $d = 0.8 * h = 320.00$   
 $N_u = 6023.953$   
 $A_g = 160000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$   
where:  
 $V_{s1} = 251327.412$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 1.5625$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 425154.451$   
 $b_w = 400.00$

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  $\theta = 1.0935846E-020$

$$y = (M_y * L_s / 3) / E_{eff} = 0.00363911 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.2576E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$$

$$\text{From table 10.5, ASCE 41-17: } E_{eff} = \text{factor} * E_c * I_g = 1.7280E+013$$

$$\text{factor} = 0.30$$

$$A_g = 160000.00$$

$$\text{Mean concrete strength: } f'_c = (f'_{c\_jacket} * \text{Area}_{jacket} + f'_{c\_core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$$

$$N = 6023.953$$

$$E_c * I_g = E_{c\_jacket} * I_{g\_jacket} + E_{c\_core} * I_{g\_core} = 5.7599E+013$$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

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

$$y_{ten} = 5.2162520E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 260.4851$$

$$d = 357.00$$

$$y = 0.30059914$$

$$A = 0.02321789$$

$$B = 0.01307844$$

$$\text{with } p_t = 0.00904198$$

$$p_c = 0.00904198$$

$$p_v = 0.00497199$$

$$N = 6023.953$$

$$b = 400.00$$

$$" = 0.12044818$$

$$y_{comp} = 2.0592201E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.29926824$$

$$A = 0.02296007$$

$$B = 0.0129165$$

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

Calculation of ratio  $I_b / I_d$

$$\text{Lap Length: } I_d / I_d, \text{min} = 0.22972747$$

$$I_b = 300.00$$

$$I_d = 1305.895$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 555.56$$

$$\text{Mean concrete strength: } f'_c = (f'_{c\_jacket} * \text{Area}_{jacket} + f'_{c\_core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr\_x}, A_{tr\_y}) = 257.6106$$

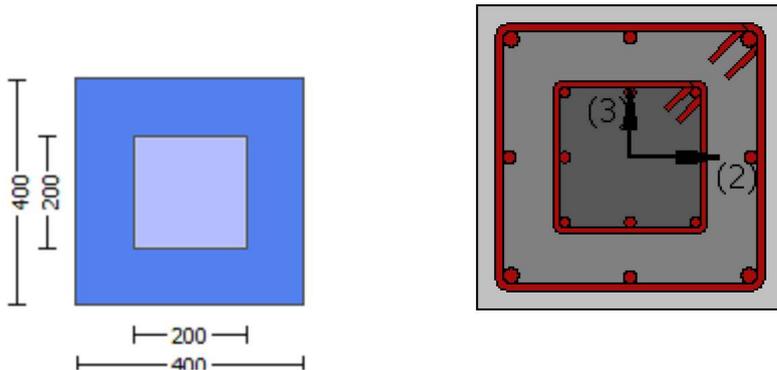
where  $A_{tr\_x}$ ,  $A_{tr\_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$   
 $n = 16.00$

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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####

Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.03547

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 3

EDGE -A-

Shear Force,  $V_a = -1.0996693E-030$

EDGE -B-

Shear Force,  $V_b = 1.0996693E-030$

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 1291.195$

-Compression:  $A_{st,com} = 1291.195$

-Middle:  $A_{st,mid} = 709.9999$

-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.21205453$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.4747E+008$

$M_{u1+} = 1.4747E+008$ , 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

$M_{u1-} = 1.4747E+008$ , 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

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.4747E+008$

$M_{u2+} = 1.4747E+008$ , 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

$M_{u2-} = 1.4747E+008$ , 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:

$\phi_u = 1.1814054E-005$

$M_u = 1.4747E+008$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi: \phi^* = \text{shear\_factor} * \text{Max}(\phi, \phi_c) = 0.00951404$$

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

$$\text{From (5.4b), TB DY: } \phi = 0.00951404$$

$$\phi_w (5.4c) = 0.02260544$$

$$\phi_{se} ((5.4d), \text{TB DY}) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$\phi_{se1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i21} = 462400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i22} = 147456.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 3.07617$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.07617$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirrups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirrups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 3.07617$$

$$\phi_{sh1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir, 1} * n_{s, 1} = 157.0796$$

$$\text{No stirrups, } n_{s, 1} = 2.00$$

$$h_1 = 400.00$$

$$\phi_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir, 2} * n_{s, 2} = 100.531$$

$$\text{No stirrups, } n_{s, 2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$F_{ywe1} = 694.45$$

$$F_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TB DY), TB DY: } \phi_c = 0.00235471$$

$$\phi_c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

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

$$l_o / l_{ou, \min} = l_b / d = 0.18378198$$

$$su_1 = 0.4 * \phi_{su1, \text{nominal}} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } \phi_{su1, \text{nominal}} = 0.08,$$

For calculation of  $\phi_{su1, \text{nominal}}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $f_{sy1} = f_{s1} / 1.2$ , from table 5.1, TB DY.

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

$$\text{with } f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$$

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

$y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/lb_{min} = 0.18378198$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 280.5991$   
 with  $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 280.5991$   
 with  $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05430052$

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

--->  
 $v < v_s, y_2$  - LHS eq.(4.5) is satisfied

--->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/ld$

-----  
Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$

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)

$= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr\_x}, A_{tr\_y}) = 257.6106$$

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

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

$$n = 16.00$$

-----  
-----  
Calculation of  $\mu_1$ -  
-----

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

$$\mu = 1.1814054E-005$$

$$\mu = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } \mu = 0.00951404$$

$$\mu_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \text{min}} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015  
shv = 0.00323248  
ftv = 336.7189  
fyv = 280.5991  
suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00  
d = 327.00  
d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

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) = 0.23357771

$M_u$  = MRc (4.14) = 1.4747E+008

$u$  =  $\mu_u$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d$  = 0.18378198

$l_b$  = 300.00

$l_d$  = 1632.369

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

$d_b$  = 16.00

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

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

MPa (22.5.3.1, ACI 318-14)

$t$  = 1.00

$s$  = 0.80

$e$  = 1.00

$c_b$  = 25.00

$K_{tr}$  = 2.57611

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

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

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

$n$  = 16.00

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

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

$u$  = 1.1814054E-005

$M_u$  = 1.4747E+008

-----  
with full section properties:

$b$  = 400.00

$d$  = 357.00

$d'$  = 43.00

$v$  = 0.0012789

$N$  = 6026.684

$f_c$  = 33.00

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

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.00951404$

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

From (5.4b), TBDY:  $\mu_u = 0.00951404$

we (5.4c) = 0.02260544

$a_{se}((5.4d), \text{TBDY}) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o_1} = 340.00$

$h_{o_1} = 340.00$

$b_{i2_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o_2} = 192.00$

$h_{o_2} = 192.00$

$b_{i2_2} = 147456.00$

$\text{psh}_{\text{min}} \cdot F_{ywe} = \text{Min}(\text{psh}_x \cdot F_{ywe}, \text{psh}_y \cdot F_{ywe}) = 3.07617$

-----  
 $\text{psh}_x \cdot F_{ywe} = \text{psh}_1 \cdot F_{ywe1} + \text{psh}_2 \cdot F_{ywe2} = 3.07617$

$\text{psh}_1$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

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

yv = 0.00101015  
shv = 0.00323248  
ftv = 336.7189  
fyv = 280.5991  
suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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

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.

$$\text{with } fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 280.5991$$

$$\text{with } Esv = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$$

$$1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.07688397$$

$$2 = Asl\_com / (b * d) * (fs2 / fc) = 0.07688397$$

$$v = Asl\_mid / (b * d) * (fsv / fc) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.09875006$$

$$2 = Asl\_com / (b * d) * (fs2 / fc) = 0.09875006$$

$$v = Asl\_mid / (b * d) * (fsv / fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.23357771$$

$$Mu = MRc (4.14) = 1.4747E+008$$

$$u = su (4.1) = 1.1814054E-005$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$$lb = 300.00$$

$$ld = 1632.369$$

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)

$$= 1$$

$$db = 16.00$$

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

Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$Ktr = 2.57611$$

$$Atr = \text{Min}(Atr\_x, Atr\_y) = 257.6106$$

where  $Atr\_x$ ,  $Atr\_y$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s\_external, s\_internal) = 250.00$$

$$n = 16.00$$

Calculation of  $Mu2$ -

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

$$u = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$v = 0.0012789$   
 $N = 6026.684$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00951404$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00951404$   
 $we (5.4c) = 0.02260544$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$   
 $ase1 = 0.24250288$   
 $bo_1 = 340.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 462400.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$   
 $bo_2 = 192.00$   
 $ho_2 = 192.00$   
 $bi2_2 = 147456.00$   
 $psh, \text{min} * Fy_{we} = \text{Min}(psh, x * Fy_{we}, psh, y * Fy_{we}) = 3.07617$

$psh, x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 3.07617$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$psh, y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 3.07617$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00392699$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00050265$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

$A_{sec} = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

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

$lo/lo_{u, \text{min}} = lb/ld = 0.18378198$   
 $su1 = 0.4 * esu1_{\text{nominal}} ((5.5), TBDY) = 0.032$

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

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

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

with  $fs1 = (fs, \text{jacket} * A_{sl, \text{ten, jacket}} + fs, \text{core} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 280.5991$

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

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$

$$su_2 = 0.00323248$$

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

$$lo/lo_{u,min} = lb/lb_{u,min} = 0.18378198$$

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

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

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 280.5991$$

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

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

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

$$lo/lo_{u,min} = lb/ld = 0.18378198$$

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 280.5991$$

$$\text{with } Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.07688397$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.07688397$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.09875006$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.09875006$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.23357771$$

$$\mu = MRc (4.14) = 1.4747E+008$$

$$u = su (4.1) = 1.1814054E-005$$

Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$$lb = 300.00$$

$$ld = 1632.369$$

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)

$$= 1$$

$$db = 16.00$$

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

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

MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

cb = 25.00

Ktr = 2.57611

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 = 16.00

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$V_{Col0} = 463630.789$

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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 9.7987490E-012$

$\nu_u = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$

$b_w = 400.00$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 463630.789$

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

$V_{Col0} = 463630.789$

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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 9.7987490E-012$

$\nu_u = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$

$bw = 400.00$

-----  
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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.03547

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = 300.00$   
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = 6.7333103E-047$   
EDGE -B-  
Shear Force,  $V_b = -6.7333103E-047$   
BOTH EDGES  
Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1291.195$   
-Compression:  $As_{c,com} = 1291.195$   
-Middle:  $As_{c,mid} = 709.9999$   
-----  
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.4747E+008$   
 $\mu_{1+} = 1.4747E+008$ , 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  
 $\mu_{1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.4747E+008$   
 $\mu_{2+} = 1.4747E+008$ , 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  
 $\mu_{2-} = 1.4747E+008$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 1.1814054E-005$   
 $M_u = 1.4747E+008$   
-----

with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu, \alpha) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu = 0.00951404$   
 $w_e (5.4c) = 0.02260544$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.24250288$   
 $ase1 = 0.24250288$   
 $bo_1 = 340.00$   
 $ho_1 = 340.00$   
 $bi2_1 = 462400.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.24250288$   
 $bo_2 = 192.00$

ho\_2 = 192.00  
bi\_2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

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

yv = 0.00101015  
shv = 0.00323248  
ftv = 336.7189

$f_{yv} = 280.5991$   
 $s_{uv} = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.18378198$   
 $s_{uv} = 0.4 * e_{suv\_nominal} ((5.5), TBDY) = 0.032$   
 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  $f_{sv} = (f_{s,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 280.5991$   
 with  $E_{sv} = (E_{s,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.07688397$   
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.04227683$

and confined core properties:

$b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.17054$   
 $c_c (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{sl,ten} / (b * d) * (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{sl,com} / (b * d) * (f_{s2} / f_c) = 0.09875006$   
 $v = A_{sl,mid} / (b * d) * (f_{sv} / f_c) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$s_u (4.9) = 0.23357771$   
 $M_u = M_{Rc} (4.14) = 1.4747E+008$   
 $u = s_u (4.1) = 1.1814054E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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

$d_b = 16.00$

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

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

MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

-----  
 Calculation of  $M_u1$ -  
 -----

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

$u = 1.1814054E-005$

$$\mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e(5.4c) = 0.02260544$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o1} = 340.00$$

$$h_{o1} = 340.00$$

$$b_{i2,1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o2} = 192.00$$

$$h_{o2} = 192.00$$

$$b_{i2,2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 3.07617$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirrups, } n_{s,1} = 2.00$$

$$h_1 = 400.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirrups, } n_{s,2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

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

$$l_o / l_{o, \min} = l_b / d = 0.18378198$$

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

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

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

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

with  $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 280.5991$   
 with  $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$   
 $y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4 \cdot esu2_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 280.5991$   
 with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 280.5991$   
 with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.07688397$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.07688397$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.09875006$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.09875006$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

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

--->  
 $v < vs, y2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$

-----  
 Calculation of ratio  $lb/ld$   
 -----

Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$

Mean strength value of all re-bars:  $f_y = 694.45$   
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$cb = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
-----  
-----  
Calculation of  $\mu_{2+}$   
-----

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

$$\mu = 1.1814054E-005$$

$$\mu_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00951404$$

$$\mu_c \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

$$h_{o_1} = 340.00$$

$$b_{i2_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o_2} = 192.00$$

$$h_{o_2} = 192.00$$

$$b_{i2_2} = 147456.00$$

$$p_{sh, \text{min}} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.07617$$

$$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $y_1 = 0.00101015$   
 $sh_1 = 0.00323248$   
 $ft_1 = 336.7189$   
 $fy_1 = 280.5991$   
 $su_1 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.18378198$   
 $su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{1\_nominal} = 0.08$ ,  
 For calculation of  $esu_{1\_nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$   
 with  $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.18378198$   
 $su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,  
 For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 280.5991$   
 with  $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.07688397$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.07688397$   
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.09875006$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$$s_u(4.9) = 0.23357771$$

$$M_u = M_{Rc}(4.14) = 1.4747E+008$$

$$u = s_u(4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

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

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of  $M_u2$ -

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

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \max(c_u, c_c) = 0.00951404$

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

From (5.4b), TBDY:  $c_u = 0.00951404$

$$w_e(5.4c) = 0.02260544$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o,1} = 340.00$$

$$h_{o,1} = 340.00$$

$$b_{i2,1} = 462400.00$$

$$a_{se2} = \max(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o,2} = 192.00$$

$$h_{o,2} = 192.00$$

$$b_{i2,2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \min(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 3.07617$$

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y1 = 0.00101015

sh1 = 0.00323248

ft1 = 336.7189

fy1 = 280.5991

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

----

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

----

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/ld

-----  
Lap Length: lb/ld = 0.18378198

lb = 300.00

ld = 1632.369

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 = 16.00

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

Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 33.00, but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.57611

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 = 16.00

-----  
Calculation of Shear Strength Vr =  $\text{Min}(Vr1, Vr2)$  = 463630.789

-----  
Calculation of Shear Strength at edge 1, Vr1 = 463630.789

Vr1 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 463630.789

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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 4.0970837E-012$   
 $V_u = 6.7333103E-047$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 6026.684$   
 $A_g = 160000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
 where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $\text{Col1} = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $\text{Col2} = 0.00$   
 $s/d = 1.5625$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$   
 $b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 463630.789$   
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$   
 $V_{\text{Col}0} = 463630.789$   
 $k_{nl} = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 4.0970837E-012$   
 $V_u = 6.7333103E-047$   
 $d = 0.8 \cdot h = 320.00$   
 $N_u = 6026.684$   
 $A_g = 160000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$   
 where:  
 $V_{s1} = 279254.914$  is calculated for jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $\text{Col1} = 1.00$   
 $s/d = 0.3125$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $\text{Col2} = 0.00$   
 $s/d = 1.5625$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$   
 $b_w = 400.00$

-----  
-----  
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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 400.00$   
External Width,  $W = 400.00$   
Internal Height,  $H = 200.00$   
Internal Width,  $W = 200.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length  $l_b = 300.00$   
No FRP Wrapping

#### Stepwise Properties

-----  
Bending Moment,  $M = -0.01979425$   
Shear Force,  $V_2 = 6825.705$   
Shear Force,  $V_3 = 5.9576024E-013$   
Axial Force,  $F = -6023.953$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1291.195$   
-Compression:  $A_{sc,com} = 1291.195$   
-Middle:  $A_{sc,mid} = 709.9999$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,jacket} = 829.3805$   
-Compression:  $A_{sc,com,jacket} = 829.3805$   
-Middle:  $A_{sc,mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,core} = 461.8141$   
-Compression:  $A_{sc,com,core} = 461.8141$   
-Middle:  $A_{sc,mid,core} = 307.8761$   
Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$   
-----

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^* u = 0.00072782$   
 $u = y + p = 0.00072782$

- Calculation of  $y$  -

$$y = (M_y * L_s / 3) / E_{eff} = 0.00072782 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.2576E+008$$

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

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.7280E+013$$

$$\text{factor} = 0.30$$

$$A_g = 160000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$$

$$N = 6023.953$$

$$E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 5.7599E+013$$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

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

$$y_{\text{ten}} = 5.2162520E-006$$

$$\text{with ((10.1), ASCE 41-17) } f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 260.4851$$

$$d = 357.00$$

$$y = 0.30059914$$

$$A = 0.02321789$$

$$B = 0.01307844$$

$$\text{with } p_t = 0.00442965$$

$$p_c = 0.00904198$$

$$p_v = 0.00497199$$

$$N = 6023.953$$

$$b = 400.00$$

$$" = 0.12044818$$

$$y_{\text{comp}} = 2.0592201E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.29926824$$

$$A = 0.02296007$$

$$B = 0.0129165$$

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

Calculation of ratio  $I_b / I_d$

$$\text{Lap Length: } I_d / I_{d,\text{min}} = 0.22972747$$

$$I_b = 300.00$$

$$I_d = 1305.895$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 555.56$$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
 - Calculation of  $p$  -  
 -----

From table 10-8:  $p = 0.00$

with:

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

$$\text{shear control ratio } V_{yE}/V_{CoIE} = 0.21205453$$

$$d = d_{\text{external}} = 357.00$$

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

$$t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$$

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

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$$

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

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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

where  $f = 2 \cdot t_f/bw$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe}/f_s$  normalises  $f$  to steel strength

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

For the normalisation  $f_s$  of jacket is used.

$$N_{UD} = 6023.953$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 33.00$$

$$f_{yIE} = (f_{y_{\text{ext\_Long\_Reinf}}} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 555.56$$

$$f_{yTE} = (f_{y_{\text{ext\_Trans\_Reinf}}} \cdot \text{Area}_{\text{ext\_Trans\_Reinf}} + f_{y_{\text{int\_Trans\_Reinf}}} \cdot \text{Area}_{\text{int\_Trans\_Reinf}}) / \text{Area}_{\text{Tot\_Trans\_Rein}} = 555.56$$

$$p_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.02305595$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

-----  
 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

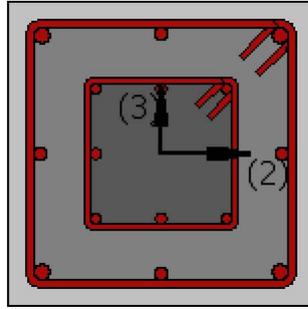
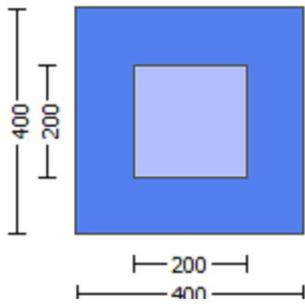
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -2.4462E+007$

Shear Force,  $V_a = -8151.474$

EDGE -B-

Bending Moment, Mb = 224.2544

Shear Force, Vb = 8151.474

BOTH EDGES

Axial Force, F = -6025.178

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 1291.195

-Compression: Aslc = 2001.195

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1291.195

-Compression: Asl,com = 1291.195

-Middle: Asl,mid = 709.9999

Mean Diameter of Tension Reinforcement, DbL,ten = 16.33333

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR = 1.0\*Vn = 331644.13

Vn ((10.3), ASCE 41-17) = knl\*VCol0 = 331644.13

VCol = 331644.13

knl = 1.00

displacement\_ductility\_demand = 0.05572044

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 = 25.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 2.4462E+007

Vu = 8151.474

d = 0.8\*h = 320.00

Nu = 6025.178

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412

where:

Vs1 = 251327.412 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 500.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 500.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 425154.451

bw = 400.00

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 = 0.00040567

y = (My\*Ls/3)/Eleff = 0.00728046 ((4.29),Biskinis Phd))

My = 1.2577E+008

Ls = M/V (with Ls > 0.1\*L and Ls < 2\*L) = 3000.924

From table 10.5, ASCE 41\_17: Eleff = factor\*Ec\*lg = 1.7280E+013

factor = 0.30  
Ag = 160000.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
N = 6025.178  
 $E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 5.7599\text{E}+013$

-----  
Calculation of Yielding Moment My

-----  
Calculation of  $\phi_y$  and My according to Annex 7 -

-----  
y = Min(  $y_{\text{ten}}$ ,  $y_{\text{com}}$  )  
 $y_{\text{ten}} = 5.2162547\text{E}-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 260.4851$   
d = 357.00  
y = 0.3005995  
A = 0.02321793  
B = 0.01307848  
with pt = 0.00904198  
pc = 0.00904198  
pv = 0.00497199  
N = 6025.178  
b = 400.00  
" = 0.12044818  
 $y_{\text{comp}} = 2.0592195\text{E}-005$   
with  $f_c = 33.00$   
Ec = 26999.444  
y = 0.29926833  
A = 0.02296005  
B = 0.0129165  
with Es = 200000.00

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

-----  
Lap Length:  $l_d/l_{d,\text{min}} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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 = 16.00

Mean strength value of all re-bars:  $f_y = 555.56$

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

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.57611

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

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 = 16.00

-----  
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

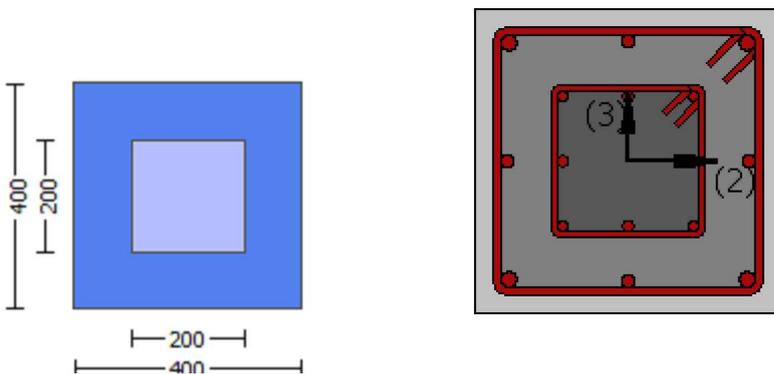
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.03547  
Element Length,  $L = 3000.00$   
Secondary 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,  $V_a = -1.0996693E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.0996693E-030$   
BOTH EDGES  
Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1291.195$   
-Compression:  $As_{c,com} = 1291.195$   
-Middle:  $As_{c,mid} = 709.9999$   
-----  
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.4747E+008$   
 $\mu_{u1+} = 1.4747E+008$ , 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  
 $\mu_{u1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.4747E+008$   
 $\mu_{u2+} = 1.4747E+008$ , 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  
 $\mu_{u2-} = 1.4747E+008$ , 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:  
 $\mu_u = 1.1814054E-005$   
 $\mu_u = 1.4747E+008$   
-----

with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\omega = (5A.5, \text{TBDY}) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \omega) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.00951404$

we (5.4c) = 0.02260544  
ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.24250288  
ase1 = 0.24250288  
bo\_1 = 340.00  
ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = (fsjacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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  $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 280.5991$

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

$y_v = 0.00101015$

$sh_v = 0.00323248$

$ft_v = 336.7189$

$fy_v = 280.5991$

$s_{uv} = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.18378198$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5,5), TBDY) = 0.032$

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  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 280.5991$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.23357771$

$Mu = MRc (4.14) = 1.4747E+008$

$u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

Calculation of Mu1-

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

$$\mu = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

Calculation of  $\mu_{2+}$

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

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $\phi_c$ :  $\phi_c = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.00951404$

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

From (5.4b), TBDY:  $\phi_c = 0.00951404$

$\phi_w$  (5.4c) = 0.02260544

$\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.24250288$

$\phi_{ase1} = 0.24250288$

$\phi_{bo_1} = 340.00$

$\phi_{ho_1} = 340.00$

$\phi_{bi_2_1} = 462400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$

$\phi_{bo_2} = 192.00$

$\phi_{ho_2} = 192.00$

$\phi_{bi_2_2} = 147456.00$

$\phi_{psh, \min} \cdot F_{ywe} = \text{Min}(\phi_{psh, x} \cdot F_{ywe}, \phi_{psh, y} \cdot F_{ywe}) = 3.07617$

$\phi_{psh, x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{ps1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

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

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 400.00$

$\phi_{ps2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

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

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 200.00$

$\phi_{psh, y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{ps1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

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

No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00050265$   
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $Asec = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c =$  confinement factor = 1.03547

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

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

$lo/lou,min = lb/ld = 0.18378198$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((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  $fs1 = (fs,jacket \cdot Asl,ten,jacket + fs,core \cdot Asl,ten,core) / Asl,ten = 280.5991$

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

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

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

$lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((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  $fs2 = (fs,jacket \cdot Asl,com,jacket + fs,core \cdot Asl,com,core) / Asl,com = 280.5991$

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

$yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$

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

$lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4 \cdot esuv\_nominal$  ((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  $fsv = (fs,jacket \cdot Asl,mid,jacket + fs,mid \cdot Asl,mid,core) / Asl,mid = 280.5991$

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

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07688397$   
 $2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.07688397$   
 $v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(fs1/fc) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(fs2/fc) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$M_u = MR_c (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

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

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of  $M_u2$ -

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

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e (5.4c) = 0.02260544$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

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

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $su_v = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.18378198$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 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  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 280.5991$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 34.17054$   
 $cc(5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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#### Calculation of ratio $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$   
 $l_b = 300.00$   
 $l_d = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $f_y = 694.45$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

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

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$V_{ColO} = 463630.789$

$kn1 = 1$  (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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 9.7987490E-012$

$\nu_u = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 488465.275$

$bw = 400.00$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 463630.789$

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

$V_{ColO} = 463630.789$

$kn1 = 1$  (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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 9.7987490E-012$

$\nu_u = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$N_u = 6026.684$

$A_g = 160000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 279254.914$

where:

$V_{s1} = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.3125$

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

$d = 160.00$

Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
Existing Column  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
#####  
External Height, H = 400.00  
External Width, W = 400.00  
Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.03547  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length lo = 300.00  
No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = 6.7333103E-047  
EDGE -B-  
Shear Force, Vb = -6.7333103E-047

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 1291.195$

-Compression:  $As_{c,com} = 1291.195$

-Middle:  $As_{mid} = 709.9999$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4747E+008$

$Mu_{1+} = 1.4747E+008$ , 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

$Mu_{1-} = 1.4747E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4747E+008$

$Mu_{2+} = 1.4747E+008$ , 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

$Mu_{2-} = 1.4747E+008$ , 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:

$\phi_u = 1.1814054E-005$

$M_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$

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

From (5.4b), TBDY:  $\phi_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_1 = 462400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_2 = 147456.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

$psh_x * F_{ywe} = psh_1 * F_{ywe1} + psh_2 * F_{ywe2} = 3.07617$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 200.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.07617  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00392699  
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> = 400.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00050265  
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> = 200.00

Asec = 160000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.45

fywe<sub>2</sub> = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y<sub>1</sub> = 0.00101015

sh<sub>1</sub> = 0.00323248

ft<sub>1</sub> = 336.7189

fy<sub>1</sub> = 280.5991

su<sub>1</sub> = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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> = 280.5991

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> = 0.00101015

sh<sub>2</sub> = 0.00323248

ft<sub>2</sub> = 336.7189

fy<sub>2</sub> = 280.5991

su<sub>2</sub> = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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> = 280.5991

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> = 0.00101015

sh<sub>v</sub> = 0.00323248

ft<sub>v</sub> = 336.7189

fy<sub>v</sub> = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 280.5991$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07688397$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07688397$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 34.17054

$cc$  (5A.5, TBDY) = 0.00235471

$c = \text{confinement factor} = 1.03547$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09875006$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09875006$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.23357771

$Mu = MRc$  (4.14) = 1.4747E+008

$u = su$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 2.57611$

$Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$

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

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

$n = 16.00$

-----  
Calculation of  $Mu_1$ -

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

$u = 1.1814054E-005$

$Mu = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$fc = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00951404$

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

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o\_1} = 340.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o\_2} = 192.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

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

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

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

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

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

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

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

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

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$

$c$  = confinement factor = 1.03547

$y_1 = 0.00101015$

$sh_1 = 0.00323248$

$ft_1 = 336.7189$

$fy_1 = 280.5991$

$su_1 = 0.00323248$

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

$l_o / l_{o, \min} = l_b / l_d = 0.18378198$

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$

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

$y_2 = 0.00101015$

$sh_2 = 0.00323248$

$ft_2 = 336.7189$

$fy_2 = 280.5991$

$su_2 = 0.00323248$

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

$l_o / l_{o, \min} = l_b / l_{b, \min} = 0.18378198$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 280.5991$   
 with  $Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 280.5991$   
 with  $Esv = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vs,y_2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} <= 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.57611$   
 $Atr = Min(Atr_x, Atr_y) = 257.6106$   
 where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = Max(s\_external, s\_internal) = 250.00$

$$n = 16.00$$

Calculation of  $\mu_{2+}$

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

$$\mu = 1.1814054E-005$$

$$\mu_{2+} = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{2+}: \mu_{2+}^* = \text{shear\_factor} * \text{Max}(\mu_{2+}, c_o) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } \mu_{2+} = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

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

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

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

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$l_b = 300.00$

$d = 1632.369$

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)

$= 1$

$d_b = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

Calculation of  $\mu_u$

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

$\mu_u = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00951404$

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

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2,1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2,2} = 147456.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.07617$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$p_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} \cdot n_{s, 1} = 157.0796$

No stirrups,  $n_{s, 1} = 2.00$

$h_1 = 400.00$

$p_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} \cdot n_{s, 2} = 100.531$

No stirrups,  $n_{s, 2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$sh1 = 0.00323248$$

$$ft1 = 336.7189$$

$$fy1 = 280.5991$$

$$su1 = 0.00323248$$

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

$$lo/lou, \text{min} = lb/ld = 0.18378198$$

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

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

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.

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

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$$

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

$$y2 = 0.00101015$$

$$sh2 = 0.00323248$$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.18378198$$

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

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

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.

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

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 280.5991$$

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

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

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

$$lo/lou, \text{min} = lb/ld = 0.18378198$$

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

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

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.

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

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$$

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.07688397$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07688397$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.23357771$$

$$\mu_u = M R_c (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

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

-----  
Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

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

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

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

$$n = 16.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

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

$$V_{Co10} = 463630.789$$

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

-----  
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:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8 * h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

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

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, Vr2 = 463630.789

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

$$VCol0 = 463630.789$$

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 = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8*h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

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

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 1.9202516E-009$

Shear Force,  $V_2 = -8151.474$

Shear Force,  $V_3 = -7.0895948E-013$

Axial Force,  $F = -6025.178$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 1291.195$

-Compression:  $A_{sc} = 2001.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

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:  $A_{sl,ten,core} = 461.8141$

-Compression:  $A_{sl,com,core} = 461.8141$

-Middle:  $A_{sl,mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.03196698$

$u = \gamma + \rho = 0.03196698$

- Calculation of  $\gamma$  -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00363911$  ((4.29), Biskinis Phd))

$M_y = 1.2577E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.7280E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$

$N = 6025.178$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

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

$y_{ten} = 5.2162547E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 260.4851$

$d = 357.00$

$y = 0.3005995$

$A = 0.02321793$

$B = 0.01307848$

with  $pt = 0.00442965$

$pc = 0.00904198$

$pv = 0.00497199$

$N = 6025.178$

$b = 400.00$

" = 0.12044818

$y_{comp} = 2.0592195E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.29926833$

$A = 0.02296005$

$B = 0.0129165$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Lap Length:  $I_d/I_{d,min} = 0.22972747$

$I_b = 300.00$

$I_d = 1305.895$

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

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

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

$n = 16.00$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.02832787$

with:

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

shear control ratio  $V_y/E/V_{col} = 0.21205453$

$d = d_{external} = 357.00$

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

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$$

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

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$$

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

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 6025.178$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 33.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 555.56$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 555.56$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.02305595$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

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

At local axis: 2

Integration Section: (a)

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## Calculation No. 11

column C1, Floor 1

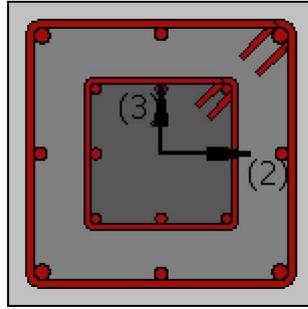
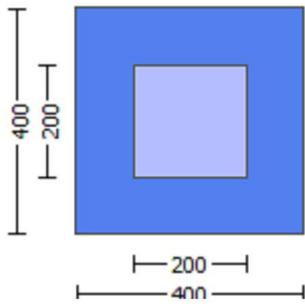
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

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

Existing Column

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

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

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 1.9202516E-009$

Shear Force,  $V_a = -7.0895948E-013$

EDGE -B-

Bending Moment, Mb = 2.0714171E-010

Shear Force, Vb = 7.0895948E-013

BOTH EDGES

Axial Force, F = -6025.178

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 1291.195

-Compression: Aslc = 2001.195

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1291.195

-Compression: Asl,com = 1291.195

-Middle: Asl,mid = 709.9999

Mean Diameter of Tension Reinforcement, DbL,ten = 16.33333

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR = 1.0\*Vn = 411960.847

Vn ((10.3), ASCE 41-17) = knl\*VCol0 = 411960.847

VCol = 411960.847

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 = 25.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 1.9202516E-009

Vu = 7.0895948E-013

d = 0.8\*h = 320.00

Nu = 6025.178

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412

where:

Vs1 = 251327.412 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 500.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 500.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

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

From (11-11), ACI 440: Vs + Vf <= 425154.451

bw = 400.00

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 = 2.8606335E-020

y = (My\*Ls/3)/Eleff = 0.00363911 ((4.29),Biskinis Phd))

My = 1.2577E+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 = 1.7280E+013

factor = 0.30  
Ag = 160000.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
N = 6025.178  
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 5.7599\text{E}+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $f_y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 5.2162547\text{E}-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 260.4851$   
d = 357.00  
y = 0.3005995  
A = 0.02321793  
B = 0.01307848  
with pt = 0.00904198  
pc = 0.00904198  
pv = 0.00497199  
N = 6025.178  
b = 400.00  
" = 0.12044818  
 $y_{\text{comp}} = 2.0592195\text{E}-005$   
with  $f_c = 33.00$   
Ec = 26999.444  
y = 0.29926833  
A = 0.02296005  
B = 0.0129165  
with Es = 200000.00

Calculation of ratio  $l_b/d$

Lap Length:  $l_d/l_{d,\text{min}} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

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

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.57611

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

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 = 16.00

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

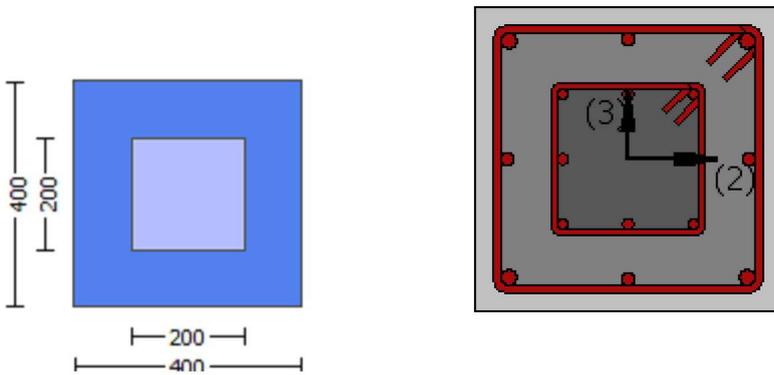
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.03547  
Element Length,  $L = 3000.00$   
Secondary 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,  $V_a = -1.0996693E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.0996693E-030$   
BOTH EDGES  
Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1291.195$   
-Compression:  $As_{c,com} = 1291.195$   
-Middle:  $As_{mid} = 709.9999$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.4747E+008$   
 $\mu_{u1+} = 1.4747E+008$ , 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  
 $\mu_{u1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.4747E+008$   
 $\mu_{u2+} = 1.4747E+008$ , 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  
 $\mu_{u2-} = 1.4747E+008$ , 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:  
 $\mu_u = 1.1814054E-005$   
 $\mu_u = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\omega = (5A.5, \text{TBDY}) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \omega) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544  
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$   
 $a_{se1} = 0.24250288$   
 $b_{o\_1} = 340.00$   
 $h_{o\_1} = 340.00$   
 $b_{i2\_1} = 462400.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$   
 $b_{o\_2} = 192.00$   
 $h_{o\_2} = 192.00$   
 $b_{i2\_2} = 147456.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 No stirups,  $n_{s\_2} = 2.00$   
 $h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 No stirups,  $n_{s\_2} = 2.00$   
 $h_2 = 200.00$

$A_{sec} = 160000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y_1 = 0.00101015$   
 $sh_1 = 0.00323248$   
 $ft_1 = 336.7189$   
 $fy_1 = 280.5991$   
 $su_1 = 0.00323248$

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

$l_{o/lou, \min} = l_b / l_d = 0.18378198$   
 $su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$

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  $fs_1 = fs_1 / 1.2$ , 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  $fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$

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

$y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$

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

$l_{o/lou, \min} = l_b / l_{b, \min} = 0.18378198$   
 $su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$

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

For calculation of  $es_{u2\_nominal}$  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  $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 280.5991$

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

$y_v = 0.00101015$

$sh_v = 0.00323248$

$ft_v = 336.7189$

$fy_v = 280.5991$

$s_{uv} = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.18378198$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5,5), TBDY) = 0.032$

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

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

For calculation of  $es_{uv\_nominal}$  and  $y_v$ ,  $sh_v, ft_v, fy_v$ , it is considered

characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_{1,ft1,fy1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 280.5991$

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

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07688397$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07688397$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 34.17054

$cc$  (5A.5, TBDY) = 0.00235471

$c$  = confinement factor = 1.03547

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09875006$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09875006$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

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

---

$su$  (4.9) = 0.23357771

$\mu_u = MR_c$  (4.14) = 1.4747E+008

$u = su$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr\_x}, A_{tr\_y}) = 257.6106$

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

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

$n = 16.00$

Calculation of Mu1-

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

$$\mu = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

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

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

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

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 280.5991

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

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 280.5991

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

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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

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

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 280.5991

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$db = 16.00$

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

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

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

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

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

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_c$ :  $\phi_c^* = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_c = 0.00951404$

$\phi_w$  (5.4c) = 0.02260544

$\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.24250288$

$\phi_{ase1} = 0.24250288$

$\phi_{bo_1} = 340.00$

$\phi_{ho_1} = 340.00$

$\phi_{bi_2_1} = 462400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$

$\phi_{bo_2} = 192.00$

$\phi_{ho_2} = 192.00$

$\phi_{bi_2_2} = 147456.00$

$\phi_{psh, \min} \cdot F_{ywe} = \text{Min}(\phi_{psh, x} \cdot F_{ywe}, \phi_{psh, y} \cdot F_{ywe}) = 3.07617$

$\phi_{psh, x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{ps1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 400.00$

$\phi_{ps2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 200.00$

$\phi_{psh, y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{ps1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(Ash2*h2/s2)/Asec = 0.00050265$   
 $Ash2 = Astir_2*ns_2 = 100.531$   
No stirups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $Asec = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c =$  confinement factor = 1.03547

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.18378198$   
 $su1 = 0.4*esu1\_nominal$  ((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  $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 280.5991$

with  $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4*esu2\_nominal$  ((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  $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 280.5991$

with  $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4*esuv\_nominal$  ((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  $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 280.5991$

with  $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$

$1 = Asl,ten/(b*d)*(fs1/fc) = 0.07688397$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.07688397$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.04227683$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(fs1/fc) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(fs2/fc) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23357771$$

$$Mu = MRc (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$$

$$n = 16.00$$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e (5.4c) = 0.02260544$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $su_v = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.18378198$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 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  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 280.5991$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 34.17054$   
 $cc(5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

#### Calculation of ratio $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$   
 $l_b = 300.00$   
 $l_d = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $f_y = 694.45$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

-----  
 -----  
 -----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 463630.789$

$Vr1 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 9.7987490E-012$

$Vu = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

$Av = 100530.965$

$fy = 555.56$

$s = 250.00$

$Vs2$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$Vf$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $Vs + Vf \leq 488465.275$

$bw = 400.00$

-----  
Calculation of Shear Strength at edge 2,  $Vr2 = 463630.789$

$Vr2 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 9.7987490E-012$

$Vu = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
Existing Column  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
#####  
External Height, H = 400.00  
External Width, W = 400.00  
Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.03547  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length lo = 300.00  
No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = 6.7333103E-047  
EDGE -B-  
Shear Force, Vb = -6.7333103E-047

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 1291.195$

-Compression:  $As_{c,com} = 1291.195$

-Middle:  $As_{mid} = 709.9999$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4747E+008$

$Mu_{1+} = 1.4747E+008$ , 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

$Mu_{1-} = 1.4747E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4747E+008$

$Mu_{2+} = 1.4747E+008$ , 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

$Mu_{2-} = 1.4747E+008$ , 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:

$\phi_u = 1.1814054E-005$

$M_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_1 = 462400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_2 = 147456.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

$psh_x * F_{ywe} = psh_1 * F_{ywe1} + psh_2 * F_{ywe2} = 3.07617$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 200.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.07617  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00392699  
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> = 400.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00050265  
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> = 200.00

Asec = 160000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.45

fywe<sub>2</sub> = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y<sub>1</sub> = 0.00101015

sh<sub>1</sub> = 0.00323248

ft<sub>1</sub> = 336.7189

fy<sub>1</sub> = 280.5991

su<sub>1</sub> = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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> = 280.5991

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> = 0.00101015

sh<sub>2</sub> = 0.00323248

ft<sub>2</sub> = 336.7189

fy<sub>2</sub> = 280.5991

su<sub>2</sub> = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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> = 280.5991

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> = 0.00101015

sh<sub>v</sub> = 0.00323248

ft<sub>v</sub> = 336.7189

fy<sub>v</sub> = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 280.5991$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07688397$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07688397$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 34.17054

$cc$  (5A.5, TBDY) = 0.00235471

$c = \text{confinement factor} = 1.03547$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09875006$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09875006$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.23357771

$Mu = MRc$  (4.14) = 1.4747E+008

$u = su$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

Mean strength value of all re-bars:  $fy = 694.45$

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 2.57611$

$Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$

where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

-----  
Calculation of  $Mu_1$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.1814054E-005$

$Mu = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o\_1} = 340.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o\_2} = 192.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$

$c$  = confinement factor = 1.03547

$y_1 = 0.00101015$

$sh_1 = 0.00323248$

$ft_1 = 336.7189$

$fy_1 = 280.5991$

$su_1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o / l_{o, \min} = l_b / l_d = 0.18378198$

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$

with  $E_{s1} = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00101015$

$sh_2 = 0.00323248$

$ft_2 = 336.7189$

$fy_2 = 280.5991$

$su_2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o / l_{o, \min} = l_b / l_{b, \min} = 0.18378198$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 280.5991$   
 with  $Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 280.5991$   
 with  $Es_v = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} <= 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.57611$   
 $Atr = Min(Atr_x, Atr_y) = 257.6106$   
 where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = Max(s\_external, s\_internal) = 250.00$

$$n = 16.00$$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.1814054E-005$$

$$\mu_{2+} = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_{2+}: \mu_{2+}^* = \text{shear\_factor} * \text{Max}(\mu_{2+}, c_o) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{2+} = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 0.18378198$$

$$su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu\_1\_nominal = 0.08,

For calculation of esu\_1\_nominal and y\_1, sh\_1,ft\_1,fy\_1, it is considered  
characteristic value fsy\_1 = fs\_1/1.2, from table 5.1, TBDY.

y\_1, sh\_1,ft\_1,fy\_1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs\_jacket * Asl,ten,jacket + fs\_core * Asl,ten,core) / Asl,ten = 280.5991$$

$$\text{with } Es_1 = (Es\_jacket * Asl,ten,jacket + Es\_core * Asl,ten,core) / Asl,ten = 200000.00$$

$$y_2 = 0.00101015$$

$$sh_2 = 0.00323248$$

$$ft_2 = 336.7189$$

$$fy_2 = 280.5991$$

$$su_2 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 0.18378198$$

$$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$$

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 280.5991$$

$$\text{with } Es_2 = (Es\_jacket * Asl,com,jacket + Es\_core * Asl,com,core) / Asl,com = 200000.00$$

$$y_v = 0.00101015$$

$$sh_v = 0.00323248$$

$$ft_v = 336.7189$$

$$fy_v = 280.5991$$

$$suv = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 0.18378198$$

$$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y\_1, sh\_1,ft\_1,fy\_1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 280.5991$$

$$\text{with } Esv = (Es\_jacket * Asl,mid,jacket + Es\_mid * Asl,mid,core) / Asl,mid = 200000.00$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.07688397$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.07688397$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.09875006$$

$$2 = Asl,com / (b * d) * (fs_2 / fc) = 0.09875006$$

$$v = Asl,mid / (b * d) * (fsv / fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.23357771$$

$$\mu_u = MRc (4.14) = 1.4747E+008$$

$$u = su (4.1) = 1.1814054E-005$$

Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$l_b = 300.00$

$d = 1632.369$

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)

$= 1$

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 694.45$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

Calculation of  $\mu_u$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$\mu_u = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$c_o$  (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2,1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2,2} = 147456.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.07617$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$p_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} \cdot n_{s, 1} = 157.0796$

No stirrups,  $n_{s, 1} = 2.00$

$h_1 = 400.00$

$p_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} \cdot n_{s, 2} = 100.531$

No stirrups,  $n_{s, 2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$sh1 = 0.00323248$$

$$ft1 = 336.7189$$

$$fy1 = 280.5991$$

$$su1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/d = 0.18378198$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$$

$$\text{with } Es1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.00101015$$

$$sh2 = 0.00323248$$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.18378198$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

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.

$$y2, sh2, ft2, fy2, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 280.5991$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/d = 0.18378198$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$$

$$\text{with } Esv = (Es_{\text{jacket}} \cdot Asl, \text{mid, jacket} + Es_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.07688397$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07688397$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23357771$$

$$M_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

Mean strength value of all re-bars:  $f_y = 694.45$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$$

where  $A_{tr,x}$ ,  $A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 16.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

$$V_{r1} = V_{Co10} ((10.3), ASCE 41-17) = k_{nl} * V_{Co10}$$

$$V_{Co10} = 463630.789$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

-----  
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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$M_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8 * h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, Vr2 = 463630.789

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

$$VCol0 = 463630.789$$

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 = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8*h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = -2.4462E+007$

Shear Force,  $V_2 = -8151.474$

Shear Force,  $V_3 = -7.0895948E-013$

Axial Force,  $F = -6025.178$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 1291.195$

-Compression:  $A_{sc} = 2001.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

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:  $A_{sl,ten,core} = 461.8141$

-Compression:  $A_{sl,com,core} = 461.8141$

-Middle:  $A_{sl,mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.03560834$

$u = \gamma + \rho = 0.03560834$

- Calculation of  $\gamma$  -

$\gamma = (M_y * L_s / 3) / E_{eff} = 0.00728046$  ((4.29), Biskinis Phd))

$M_y = 1.2577E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3000.924

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.7280E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$

$N = 6025.178$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 5.2162547E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 260.4851$

$d = 357.00$

$y = 0.3005995$

$A = 0.02321793$

$B = 0.01307848$

with  $pt = 0.00442965$

$pc = 0.00904198$

$pv = 0.00497199$

$N = 6025.178$

$b = 400.00$

" = 0.12044818

$y_{comp} = 2.0592195E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.29926833$

$A = 0.02296005$

$B = 0.0129165$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Lap Length:  $I_d/I_{d,min} = 0.22972747$

$I_b = 300.00$

$I_d = 1305.895$

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

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$

where  $A_{tr,x}$ ,  $A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.02832787$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b/I_d < 1$

shear control ratio  $V_y/E/V_{col}/E = 0.21205453$

$d = d_{external} = 357.00$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$$

Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$$

Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 6025.178$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 33.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 555.56$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 555.56$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.02305595$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

-----  
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

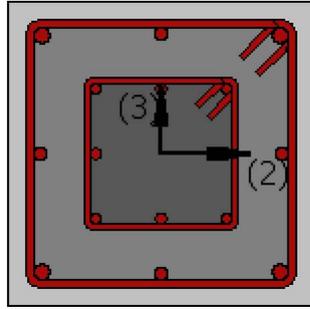
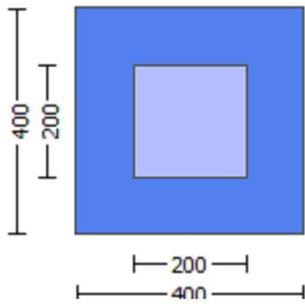
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -2.4462E+007$

Shear Force,  $V_a = -8151.474$

EDGE -B-

Bending Moment, Mb = 224.2544

Shear Force, Vb = 8151.474

BOTH EDGES

Axial Force, F = -6025.178

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Aslc = 3292.389

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1291.195

-Compression: Asl,com = 1291.195

-Middle: Asl,mid = 709.9999

Mean Diameter of Tension Reinforcement, DbL,ten = 16.33333

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR = 1.0\*Vn = 411960.847

Vn ((10.3), ASCE 41-17) = knl\*VCol0 = 411960.847

VCol = 411960.847

knl = 1.00

displacement\_ductility\_demand = 0.29173319

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 = 25.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 224.2544

Vu = 8151.474

d = 0.8\*h = 320.00

Nu = 6025.178

Ag = 160000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 251327.412

where:

Vs1 = 251327.412 is calculated for jacket, with:

d = 320.00

Av = 157079.633

fy = 500.00

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.3125

Vs2 = 0.00 is calculated for core, with:

d = 160.00

Av = 100530.965

fy = 500.00

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 425154.451

bw = 400.00

displacement\_ductility\_demand is calculated as / y

- Calculation of / y for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 0.00021233

y = (My\*Ls/3)/Eleff = 0.00072782 ((4.29),Biskinis Phd))

My = 1.2577E+008

Ls = M/V (with Ls > 0.1\*L and Ls < 2\*L) = 300.00

From table 10.5, ASCE 41\_17: Eleff = factor\*Ec\*Ig = 1.7280E+013

factor = 0.30  
Ag = 160000.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
N = 6025.178  
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 5.7599\text{E}+013$

-----  
Calculation of Yielding Moment My

-----  
Calculation of  $f_y$  and My according to Annex 7 -

-----  
y = Min(  $y_{\text{ten}}$ ,  $y_{\text{com}}$  )  
 $y_{\text{ten}} = 5.2162547\text{E}-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 260.4851$   
d = 357.00  
y = 0.3005995  
A = 0.02321793  
B = 0.01307848  
with pt = 0.00904198  
pc = 0.00904198  
pv = 0.00497199  
N = 6025.178  
b = 400.00  
" = 0.12044818  
 $y_{\text{comp}} = 2.0592195\text{E}-005$   
with  $f_c = 33.00$   
Ec = 26999.444  
y = 0.29926833  
A = 0.02296005  
B = 0.0129165  
with Es = 200000.00

-----  
Calculation of ratio  $l_b/d$

-----  
Lap Length:  $l_d/l_{d,\text{min}} = 0.22972747$

l<sub>b</sub> = 300.00

l<sub>d</sub> = 1305.895

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 = 16.00

Mean strength value of all re-bars:  $f_y = 555.56$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

K<sub>tr</sub> = 2.57611

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 = 16.00

-----  
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

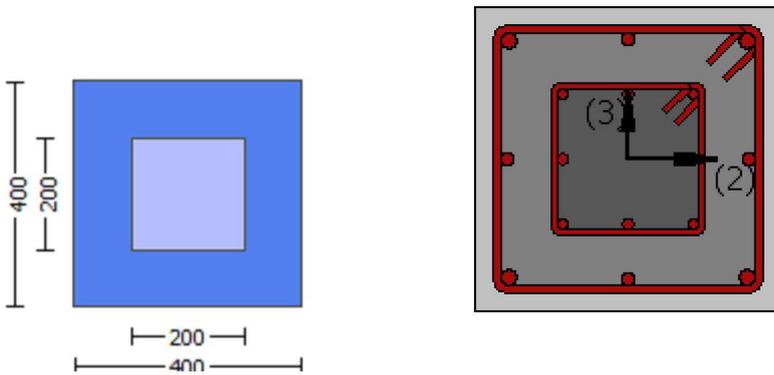
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

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,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.03547  
Element Length,  $L = 3000.00$   
Secondary 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,  $V_a = -1.0996693E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.0996693E-030$   
BOTH EDGES  
Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1291.195$   
-Compression:  $As_{c,com} = 1291.195$   
-Middle:  $As_{mid} = 709.9999$   
-----  
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.4747E+008$   
 $\mu_{1+} = 1.4747E+008$ , 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  
 $\mu_{1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.4747E+008$   
 $\mu_{2+} = 1.4747E+008$ , 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  
 $\mu_{2-} = 1.4747E+008$ , 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  $\mu$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu = 1.1814054E-005$   
 $\mu_u = 1.4747E+008$   
-----

with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\omega (5A.5, \text{TBDY}) = 0.002$   
Final value of  $\mu$ :  $\mu^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_c = 0.00951404$

$w_e$  (5.4c) = 0.02260544  
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$   
 $a_{se1} = 0.24250288$   
 $bo\_1 = 340.00$   
 $ho\_1 = 340.00$   
 $bi2\_1 = 462400.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$   
 $bo\_2 = 192.00$   
 $ho\_2 = 192.00$   
 $bi2\_2 = 147456.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$   
 $ps1$  (external) =  $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$   
 $ps1$  (external) =  $(A_{sh1} * h1 / s1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(A_{sh2} * h2 / s2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 200.00$

$A_{sec} = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$lo/lou, \min = lb/l_d = 0.18378198$

$su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl, ten, jacket} + fs_{core} * A_{sl, ten, core}) / A_{sl, ten} = 280.5991$

with  $Es1 = (Es_{jacket} * A_{sl, ten, jacket} + Es_{core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$lo/lou, \min = lb/l_b, \min = 0.18378198$

$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$

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  $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 280.5991$

with  $Es_2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.00101015$

$sh_v = 0.00323248$

$ft_v = 336.7189$

$fy_v = 280.5991$

$s_{uv} = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.18378198$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5,5), TBDY) = 0.032$

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  $f_{sv} = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 280.5991$

with  $Es_v = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 34.17054$

$cc (5A.5, TBDY) = 0.00235471$

$c = \text{confinement factor} = 1.03547$

$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$

$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$

$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.23357771$

$\mu_u = MR_c (4.14) = 1.4747E+008$

$u = su (4.1) = 1.1814054E-005$

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

Mean strength value of all re-bars:  $fy = 694.45$

Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area_{jacket} + f'_{c\_core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr\_x}, A_{tr\_y}) = 257.6106$

where  $A_{tr\_x}$ ,  $A_{tr\_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

No stirrups,  $n_{s\_1} = 2.00$

$$h_1 = 400.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

No stirrups,  $n_{s\_2} = 2.00$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 694.45$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_c$ :  $\phi_c = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_c = 0.00951404$

$\phi_w$  (5.4c) = 0.02260544

$\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.24250288$

$\phi_{ase1} = 0.24250288$

$\phi_{bo_1} = 340.00$

$\phi_{ho_1} = 340.00$

$\phi_{bi_1} = 462400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$

$\phi_{bo_2} = 192.00$

$\phi_{ho_2} = 192.00$

$\phi_{bi_2} = 147456.00$

$\phi_{psh, \min} \cdot F_{ywe} = \text{Min}(\phi_{psh, x} \cdot F_{ywe}, \phi_{psh, y} \cdot F_{ywe}) = 3.07617$

$\phi_{psh, x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{psh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 400.00$

$\phi_{psh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 200.00$

$\phi_{psh, y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{psh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00050265$   
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $Asec = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.18378198$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((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  $fs1 = (fs,jacket \cdot Asl,ten,jacket + fs,core \cdot Asl,ten,core) / Asl,ten = 280.5991$

with  $Es1 = (Es,jacket \cdot Asl,ten,jacket + Es,core \cdot Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((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  $fs2 = (fs,jacket \cdot Asl,com,jacket + fs,core \cdot Asl,com,core) / Asl,com = 280.5991$

with  $Es2 = (Es,jacket \cdot Asl,com,jacket + Es,core \cdot Asl,com,core) / Asl,com = 200000.00$

$yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4 \cdot esuv\_nominal$  ((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  $fsv = (fs,jacket \cdot Asl,mid,jacket + fs,mid \cdot Asl,mid,core) / Asl,mid = 280.5991$

with  $Esv = (Es,jacket \cdot Asl,mid,jacket + Es,mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07688397$   
 $2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.07688397$   
 $v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 34.17054$$

$$cc \text{ (5A.5, TBDY)} = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(fs1/fc) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(fs2/fc) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u \text{ (4.9)} = 0.23357771$$

$$M_u = MR_c \text{ (4.14)} = 1.4747E+008$$

$$u = s_u \text{ (4.1)} = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$$

$$n = 16.00$$

-----  
Calculation of  $M_u2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $su_v = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.18378198$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 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  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 280.5991$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 34.17054$   
 $cc(5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

#### Calculation of ratio $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$   
 $l_b = 300.00$   
 $l_d = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $f_y = 694.45$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

-----  
 -----  
 -----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 463630.789$

$Vr1 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 9.7987490E-012$

$Vu = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

$Av = 100530.965$

$fy = 555.56$

$s = 250.00$

$Vs2$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$Vf$  ((11-3)-(11.4), ACI 440) =  $0.00$

From (11-11), ACI 440:  $Vs + Vf \leq 488465.275$

$bw = 400.00$

-----  
Calculation of Shear Strength at edge 2,  $Vr2 = 463630.789$

$Vr2 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$Mu = 9.7987490E-012$

$Vu = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
Existing Column  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
#####  
External Height, H = 400.00  
External Width, W = 400.00  
Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.03547  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length lo = 300.00  
No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = 6.7333103E-047  
EDGE -B-  
Shear Force, Vb = -6.7333103E-047

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{ten} = 1291.195$

-Compression:  $As_{com} = 1291.195$

-Middle:  $As_{mid} = 709.9999$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4747E+008$

$Mu_{1+} = 1.4747E+008$ , 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

$Mu_{1-} = 1.4747E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4747E+008$

$Mu_{2+} = 1.4747E+008$ , 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

$Mu_{2-} = 1.4747E+008$ , 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:

$\phi_u = 1.1814054E-005$

$M_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_1 = 462400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_2 = 147456.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

$psh_x * F_{ywe} = psh_1 * F_{ywe1} + psh_2 * F_{ywe2} = 3.07617$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirups, ns<sub>2</sub> = 2.00  
h<sub>2</sub> = 200.00

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 3.07617  
ps<sub>1</sub> (external) = (Ash<sub>1</sub>\*h<sub>1</sub>/s<sub>1</sub>)/Asec = 0.00392699  
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> = 400.00  
ps<sub>2</sub> (internal) = (Ash<sub>2</sub>\*h<sub>2</sub>/s<sub>2</sub>)/Asec = 0.00050265  
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> = 200.00

Asec = 160000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.45

fywe<sub>2</sub> = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y<sub>1</sub> = 0.00101015

sh<sub>1</sub> = 0.00323248

ft<sub>1</sub> = 336.7189

fy<sub>1</sub> = 280.5991

su<sub>1</sub> = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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> = 280.5991

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> = 0.00101015

sh<sub>2</sub> = 0.00323248

ft<sub>2</sub> = 336.7189

fy<sub>2</sub> = 280.5991

su<sub>2</sub> = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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> = 280.5991

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> = 0.00101015

sh<sub>v</sub> = 0.00323248

ft<sub>v</sub> = 336.7189

fy<sub>v</sub> = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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> = 0.18378198

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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 280.5991$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07688397$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07688397$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 34.17054

$cc$  (5A.5, TBDY) = 0.00235471

$c = \text{confinement factor} = 1.03547$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09875006$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09875006$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---

$su$  (4.9) = 0.23357771

$Mu = MRc$  (4.14) = 1.4747E+008

$u = su$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

Mean strength value of all re-bars:  $fy = 694.45$

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 2.57611$

$Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$

where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

-----  
Calculation of  $Mu_1$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.1814054E-005$

$Mu = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o\_1} = 340.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o\_2} = 192.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$

$c$  = confinement factor = 1.03547

$y_1 = 0.00101015$

$sh_1 = 0.00323248$

$ft_1 = 336.7189$

$fy_1 = 280.5991$

$su_1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 0.18378198$

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 280.5991$

with  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00101015$

$sh_2 = 0.00323248$

$ft_2 = 336.7189$

$fy_2 = 280.5991$

$su_2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.18378198$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs_2 = fs_2/1.2$ , 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  $fs_2 = (fs\_jacket * Asl\_com\_jacket + fs\_core * Asl\_com\_core) / Asl\_com = 280.5991$   
 with  $Es_2 = (Es\_jacket * Asl\_com\_jacket + Es\_core * Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsyv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsyv/1.2$ , 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  $fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 280.5991$   
 with  $Es_v = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} <= 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = Min(A_{tr\_x}, A_{tr\_y}) = 257.6106$   
 where  $A_{tr\_x}, A_{tr\_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = Max(s_{external}, s_{internal}) = 250.00$

$$n = 16.00$$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.1814054E-005$$

$$\mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.00951404$$

$$\mu_{we} \text{ (5.4c)} = 0.02260544$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.24250288$$

$$\mu_{ase1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 3.07617$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.07617$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.07617$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 694.45$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

Calculation of  $\mu_u$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$\mu_u = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$c_o$  (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2,1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2,2} = 147456.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 3.07617$

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$p_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s1} = 157.0796$

No stirrups,  $n_{s1} = 2.00$

$h_1 = 400.00$

$p_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s2} = 100.531$

No stirrups,  $n_{s2} = 2.00$

$h_2 = 200.00$

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$sh1 = 0.00323248$$

$$ft1 = 336.7189$$

$$fy1 = 280.5991$$

$$su1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/d = 0.18378198$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$$

$$\text{with } Es1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.00101015$$

$$sh2 = 0.00323248$$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.18378198$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

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.

$$y2, sh2, ft2, fy2, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 280.5991$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/d = 0.18378198$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$$

$$\text{with } Esv = (Es_{\text{jacket}} \cdot Asl, \text{mid, jacket} + Es_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.07688397$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.07688397$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23357771$$

$$\mu_u = M_{Rc} (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$$

where  $A_{tr,x}$ ,  $A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 16.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 463630.789$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

-----  
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:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8 * h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, Vr2 = 463630.789

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

$$VCol0 = 463630.789$$

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 = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8*h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 2.0714171E-010$

Shear Force,  $V_2 = 8151.474$

Shear Force,  $V_3 = 7.0895948E-013$

Axial Force,  $F = -6025.178$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

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:  $A_{sl,ten,core} = 461.8141$

-Compression:  $A_{sl,com,core} = 461.8141$

-Middle:  $A_{sl,mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.03196698$

$u = \gamma + \rho = 0.03196698$

- Calculation of  $\gamma$  -

$\gamma = (My * Ls / 3) / E_{eff} = 0.00363911$  ((4.29), Biskinis Phd))

$My = 1.2577E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.7280E+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$

$N = 6025.178$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 5.7599E+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 5.2162547E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 260.4851$

$d = 357.00$

$y = 0.3005995$

$A = 0.02321793$

$B = 0.01307848$

with  $pt = 0.00442965$

$pc = 0.00904198$

$pv = 0.00497199$

$N = 6025.178$

$b = 400.00$

" = 0.12044818

$y_{comp} = 2.0592195E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.29926833$

$A = 0.02296005$

$B = 0.0129165$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Lap Length:  $I_d/I_{d,min} = 0.22972747$

$I_b = 300.00$

$I_d = 1305.895$

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

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$

where  $A_{tr,x}$ ,  $A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.02832787$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b/I_d < 1$

shear control ratio  $V_y E / V_{col} I_E = 0.21205453$

$d = d_{external} = 357.00$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$$

$A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$$

$A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 6025.178$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 33.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 555.56$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 555.56$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.02305595$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

-----  
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

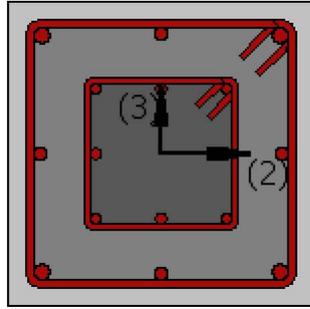
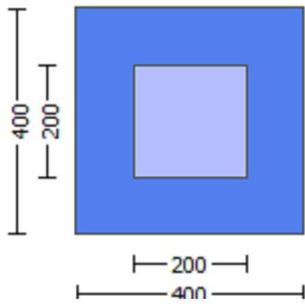
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

Existing Column

New material: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material: Steel Strength,  $f_s = f_{sm} = 555.56$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_o = l_b = 300.00$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = 1.9202516E-009$

Shear Force,  $V_a = -7.0895948E-013$

EDGE -B-

Bending Moment,  $M_b = 2.0714171E-010$

Shear Force,  $V_b = 7.0895948E-013$

BOTH EDGES

Axial Force,  $F = -6025.178$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{s,ten} = 1291.195$

-Compression:  $A_{s,com} = 1291.195$

-Middle:  $A_{s,mid} = 709.9999$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 411960.847$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI0} = 411960.847$

$V_{CoI} = 411960.847$

$k_n = 1.00$

$displacement\_ductility\_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa ((22.5.3.1), ACI 318-14)

$M/Vd = 2.00$

$M_u = 2.0714171E-010$

$V_u = 7.0895948E-013$

$d = 0.8 \cdot h = 320.00$

$N_u = 6025.178$

$A_g = 160000.00$

From ((11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 251327.412$

where:

$V_{s1} = 251327.412$  is calculated for jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From ((11-11), ACI 440:  $V_s + V_f \leq 425154.451$

$bw = 400.00$

$displacement\_ductility\_demand$  is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END B -

for rotation axis 2 and integ. section (b)

From analysis, chord rotation  $\phi = 1.3038466E-020$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00363911$  ((4.29), Biskinis Phd))

$M_y = 1.2577E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.7280E+013$

factor = 0.30  
Ag = 160000.00  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
N = 6025.178  
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 5.7599E+013$

-----  
Calculation of Yielding Moment My

-----  
Calculation of  $f_y$  and My according to Annex 7 -

-----  
y = Min(  $y_{\text{ten}}$ ,  $y_{\text{com}}$  )  
 $y_{\text{ten}} = 5.2162547E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 260.4851$   
d = 357.00  
y = 0.3005995  
A = 0.02321793  
B = 0.01307848  
with pt = 0.00904198  
pc = 0.00904198  
pv = 0.00497199  
N = 6025.178  
b = 400.00  
" = 0.12044818  
 $y_{\text{comp}} = 2.0592195E-005$   
with  $f_c = 33.00$   
Ec = 26999.444  
y = 0.29926833  
A = 0.02296005  
B = 0.0129165  
with Es = 200000.00

-----  
Calculation of ratio  $l_b/d$

-----  
Lap Length:  $l_d/l_{d,\text{min}} = 0.22972747$

$l_b = 300.00$

$l_d = 1305.895$

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

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 2.57611

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

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 = 16.00

-----  
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

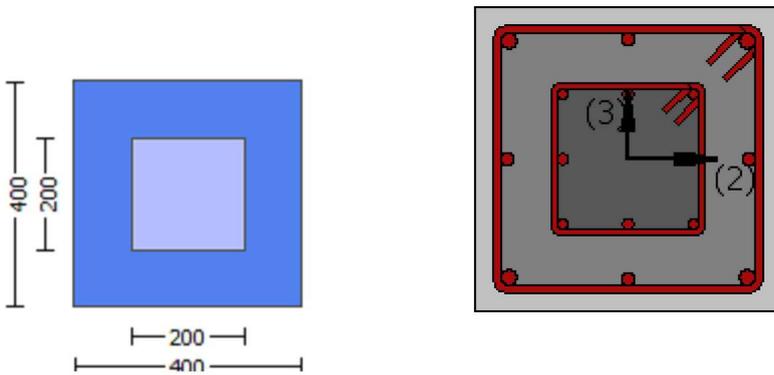
Limit State: Life Safety (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.03547  
Element Length,  $L = 3000.00$   
Secondary 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,  $V_a = -1.0996693E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.0996693E-030$   
BOTH EDGES  
Axial Force,  $F = -6026.684$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1291.195$   
-Compression:  $As_{c,com} = 1291.195$   
-Middle:  $As_{c,mid} = 709.9999$   
-----  
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.4747E+008$   
 $\mu_{u1+} = 1.4747E+008$ , 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  
 $\mu_{u1-} = 1.4747E+008$ , 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  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.4747E+008$   
 $\mu_{u2+} = 1.4747E+008$ , 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  
 $\mu_{u2-} = 1.4747E+008$ , 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:  
 $\mu_u = 1.1814054E-005$   
 $\mu_u = 1.4747E+008$   
-----

with full section properties:

$b = 400.00$   
 $d = 357.00$   
 $d' = 43.00$   
 $v = 0.0012789$   
 $N = 6026.684$   
 $f_c = 33.00$   
 $\alpha_1 (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00951404$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544  
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$   
 $a_{se1} = 0.24250288$   
 $b_{o\_1} = 340.00$   
 $h_{o\_1} = 340.00$   
 $b_{i2\_1} = 462400.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$   
 $b_{o\_2} = 192.00$   
 $h_{o\_2} = 192.00$   
 $b_{i2\_2} = 147456.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 No stirups,  $n_{s\_2} = 2.00$   
 $h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$   
 $p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 400.00$   
 $p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 No stirups,  $n_{s\_2} = 2.00$   
 $h_2 = 200.00$

$A_{sec} = 160000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$

$y_1 = 0.00101015$   
 $sh_1 = 0.00323248$   
 $ft_1 = 336.7189$   
 $fy_1 = 280.5991$   
 $su_1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$l_o / l_{ou, \min} = l_b / l_d = 0.18378198$   
 $su_1 = 0.4 * esu_{1\_nominal} ((5.5), TBDY) = 0.032$

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  $fs_{y1} = fs_1 / 1.2$ , 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  $fs_1 = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 280.5991$

with  $Es_1 = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.00101015$   
 $sh_2 = 0.00323248$   
 $ft_2 = 336.7189$   
 $fy_2 = 280.5991$   
 $su_2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.18378198$   
 $su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,

For calculation of  $es_{u2\_nominal}$  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  $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 280.5991$

with  $Es_2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.00101015$

$sh_v = 0.00323248$

$ft_v = 336.7189$

$fy_v = 280.5991$

$s_{uv} = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.18378198$

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5,5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{uv\_nominal} = 0.08$ ,

considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $es_{uv\_nominal}$  and  $y_v$ ,  $sh_v, ft_v, fy_v$ , it is considered

characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_{1,ft1,fy1}$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 280.5991$

with  $Es_v = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07688397$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07688397$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 34.17054

$cc$  (5A.5, TBDY) = 0.00235471

$c$  = confinement factor = 1.03547

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09875006$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09875006$

$v = A_{sl,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---

$su$  (4.9) = 0.23357771

$\mu_u = MR_c$  (4.14) = 1.4747E+008

$u = su$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

Mean strength value of all re-bars:  $fy = 694.45$

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr\_x}, A_{tr\_y}) = 257.6106$

where  $A_{tr\_x}$ ,  $A_{tr\_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.1814054E-005$$

$$Mu = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.00951404$$

$$w_e \text{ (5.4c)} = 0.02260544$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirrups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirrups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

$$su_1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

-----  
Calculation of ratio lb/d

Lap Length:  $l_b/l_d = 0.18378198$

$l_b = 300.00$

$l_d = 1632.369$

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)

$= 1$

$db = 16.00$

Mean strength value of all re-bars:  $f_y = 694.45$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_c$ :  $\phi_c = \text{shear\_factor} \cdot \text{Max}(\phi_c, \phi_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_c = 0.00951404$

$\phi_w$  (5.4c) = 0.02260544

$\phi_{ase}$  ((5.4d), TBDY) =  $(\phi_{ase1} \cdot A_{ext} + \phi_{ase2} \cdot A_{int}) / A_{sec} = 0.24250288$

$\phi_{ase1} = 0.24250288$

$\phi_{bo_1} = 340.00$

$\phi_{ho_1} = 340.00$

$\phi_{bi_2_1} = 462400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.24250288$

$\phi_{bo_2} = 192.00$

$\phi_{ho_2} = 192.00$

$\phi_{bi_2_2} = 147456.00$

$\phi_{psh, \min} \cdot F_{ywe} = \text{Min}(\phi_{psh, x} \cdot F_{ywe}, \phi_{psh, y} \cdot F_{ywe}) = 3.07617$

$\phi_{psh, x} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{ps1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups,  $n_{s_1} = 2.00$

$h_1 = 400.00$

$\phi_{ps2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$

No stirrups,  $n_{s_2} = 2.00$

$h_2 = 200.00$

$\phi_{psh, y} \cdot F_{ywe} = \phi_{psh1} \cdot F_{ywe1} + \phi_{psh2} \cdot F_{ywe2} = 3.07617$

$\phi_{ps1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} \cdot n_{s_1} = 157.0796$

No stirrups,  $ns_1 = 2.00$   
 $h1 = 400.00$   
 $ps2$  (internal) =  $(Ash2 \cdot h2 / s2) / Asec = 0.00050265$   
 $Ash2 = Astir\_2 \cdot ns_2 = 100.531$   
No stirrups,  $ns_2 = 2.00$   
 $h2 = 200.00$

-----  
 $Asec = 160000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00235471$   
 $c =$  confinement factor = 1.03547

$y1 = 0.00101015$   
 $sh1 = 0.00323248$   
 $ft1 = 336.7189$   
 $fy1 = 280.5991$   
 $su1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.18378198$   
 $su1 = 0.4 \cdot esu1\_nominal$  ((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  $fs1 = (fs,jacket \cdot Asl,ten,jacket + fs,core \cdot Asl,ten,core) / Asl,ten = 280.5991$

with  $Es1 = (Es,jacket \cdot Asl,ten,jacket + Es,core \cdot Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.00101015$   
 $sh2 = 0.00323248$   
 $ft2 = 336.7189$   
 $fy2 = 280.5991$   
 $su2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/lb,min = 0.18378198$   
 $su2 = 0.4 \cdot esu2\_nominal$  ((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  $fs2 = (fs,jacket \cdot Asl,com,jacket + fs,core \cdot Asl,com,core) / Asl,com = 280.5991$

with  $Es2 = (Es,jacket \cdot Asl,com,jacket + Es,core \cdot Asl,com,core) / Asl,com = 200000.00$

$yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.18378198$   
 $suv = 0.4 \cdot esuv\_nominal$  ((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  $fsv = (fs,jacket \cdot Asl,mid,jacket + fs,mid \cdot Asl,mid,core) / Asl,mid = 280.5991$

with  $Esv = (Es,jacket \cdot Asl,mid,jacket + Es,mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.07688397$   
 $2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.07688397$   
 $v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 34.17054$$

$$cc (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(fs1/fc) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(fs2/fc) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(fsv/fc) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23357771$$

$$M_u = MR_c (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Lap Length:  $l_b/l_d = 0.18378198$

$$l_b = 300.00$$

$$l_d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$$

$$n = 16.00$$

-----  
Calculation of  $M_u2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 1.1814054E-005$$

$$M_u = 1.4747E+008$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00951404$$

$$w_e (5.4c) = 0.02260544$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$$

$$a_{se1} = 0.24250288$$

$$b_{o_1} = 340.00$$

ho\_1 = 340.00  
bi2\_1 = 462400.00  
ase2 = Max(ase1,ase2) = 0.24250288  
bo\_2 = 192.00  
ho\_2 = 192.00  
bi2\_2 = 147456.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 3.07617

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471  
c = confinement factor = 1.03547

y1 = 0.00101015  
sh1 = 0.00323248  
ft1 = 336.7189  
fy1 = 280.5991  
su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015  
sh2 = 0.00323248  
ft2 = 336.7189  
fy2 = 280.5991  
su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198  
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 = 280.5991

with  $E_s2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.00101015$   
 $sh_v = 0.00323248$   
 $ft_v = 336.7189$   
 $fy_v = 280.5991$   
 $su_v = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{o,min} = l_b/l_d = 0.18378198$   
 $su_v = 0.4 \cdot esuv\_nominal((5.5), TBDY) = 0.032$   
 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  $fsv = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 280.5991$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.07688397$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.07688397$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $f_{cc}(5A.2, TBDY) = 34.17054$   
 $cc(5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09875006$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09875006$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

-----

Calculation of ratio  $l_b/l_d$

-----  
 Lap Length:  $l_b/l_d = 0.18378198$   
 $l_b = 300.00$   
 $l_d = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $f_y = 694.45$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $K_{tr} = 2.57611$   
 $A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$   
 where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = \text{Max}(s_{external}, s_{internal}) = 250.00$   
 $n = 16.00$

-----  
 -----  
 -----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 463630.789$

$Vr1 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$Mu = 9.7987490E-012$

$Vu = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

$Av = 100530.965$

$fy = 555.56$

$s = 250.00$

$Vs2$  is multiplied by  $Col2 = 0.00$

$s/d = 1.5625$

$Vf$  ((11-3)-(11.4), ACI 440) =  $0.00$

From (11-11), ACI 440:  $Vs + Vf \leq 488465.275$

$bw = 400.00$

-----  
Calculation of Shear Strength at edge 2,  $Vr2 = 463630.789$

$Vr2 = VCol$  ((10.3), ASCE 41-17) =  $knl * VColO$

$VColO = 463630.789$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$Mu = 9.7987490E-012$

$Vu = 1.0996693E-030$

$d = 0.8 * h = 320.00$

$Nu = 6026.684$

$Ag = 160000.00$

From (11.5.4.8), ACI 318-14:  $Vs = Vs1 + Vs2 = 279254.914$

where:

$Vs1 = 279254.914$  is calculated for jacket, with:

$d = 320.00$

$Av = 157079.633$

$fy = 555.56$

$s = 100.00$

$Vs1$  is multiplied by  $Col1 = 1.00$

$s/d = 0.3125$

$Vs2 = 0.00$  is calculated for core, with:

$d = 160.00$

Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 488465.275  
bw = 400.00

-----  
-----  
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 Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
Existing Column  
New material: Steel Strength, fs = 1.25\*fsm = 694.45  
#####  
External Height, H = 400.00  
External Width, W = 400.00  
Internal Height, H = 200.00  
Internal Width, W = 200.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.03547  
Element Length, L = 3000.00  
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Lap Length lo = 300.00  
No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force, Va = 6.7333103E-047  
EDGE -B-  
Shear Force, Vb = -6.7333103E-047

BOTH EDGES

Axial Force,  $F = -6026.684$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 1291.195$

-Compression:  $As_{c,com} = 1291.195$

-Middle:  $As_{mid} = 709.9999$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.21205453$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 98315.01$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.4747E+008$

$Mu_{1+} = 1.4747E+008$ , 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

$Mu_{1-} = 1.4747E+008$ , 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

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.4747E+008$

$Mu_{2+} = 1.4747E+008$ , 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

$Mu_{2-} = 1.4747E+008$ , 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:

$\phi_u = 1.1814054E-005$

$M_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$ase$  ((5.4d), TBDY) =  $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.24250288$

$ase_1 = 0.24250288$

$bo_1 = 340.00$

$ho_1 = 340.00$

$bi_1 = 462400.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.24250288$

$bo_2 = 192.00$

$ho_2 = 192.00$

$bi_2 = 147456.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 3.07617$

$psh_x * F_{ywe} = psh_1 * F_{ywe1} + psh_2 * F_{ywe2} = 3.07617$

$ps_1$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h_1 = 400.00$

$ps_2$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirups, ns\_2 = 2.00  
h2 = 200.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 3.07617  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00392699  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 400.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00050265  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 200.00

Asec = 160000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00235471

c = confinement factor = 1.03547

y1 = 0.00101015

sh1 = 0.00323248

ft1 = 336.7189

fy1 = 280.5991

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 280.5991$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.07688397$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.07688397$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.04227683$

and confined core properties:

$b = 340.00$

$d = 327.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 34.17054

$cc$  (5A.5, TBDY) = 0.00235471

$c = \text{confinement factor} = 1.03547$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09875006$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09875006$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05430052$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---

$su$  (4.9) = 0.23357771

$Mu = MRc$  (4.14) = 1.4747E+008

$u = su$  (4.1) = 1.1814054E-005

-----  
Calculation of ratio  $lb/ld$

Lap Length:  $lb/ld = 0.18378198$

$lb = 300.00$

$ld = 1632.369$

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

$db = 16.00$

Mean strength value of all re-bars:  $fy = 694.45$

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$cb = 25.00$

$Ktr = 2.57611$

$Atr = \text{Min}(Atr_x, Atr_y) = 257.6106$

where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{external}, s_{internal}) = 250.00$

$n = 16.00$

-----  
Calculation of  $Mu_1$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 1.1814054E-005$

$Mu = 1.4747E+008$

-----  
with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o\_1} = 340.00$

$h_{o\_1} = 340.00$

$b_{i2\_1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o\_2} = 192.00$

$h_{o\_2} = 192.00$

$b_{i2\_2} = 147456.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 3.07617$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 3.07617$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 400.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 200.00$

$A_{sec} = 160000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00235471$

$c$  = confinement factor = 1.03547

$y_1 = 0.00101015$

$sh_1 = 0.00323248$

$ft_1 = 336.7189$

$fy_1 = 280.5991$

$su_1 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 0.18378198$

$su_1 = 0.4 * e_{su1\_nominal}$  ((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  $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 280.5991$

with  $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.00101015$

$sh_2 = 0.00323248$

$ft_2 = 336.7189$

$fy_2 = 280.5991$

$su_2 = 0.00323248$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 0.18378198$

$su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs\_jacket * Asl\_com\_jacket + fs\_core * Asl\_com\_core) / Asl\_com = 280.5991$   
 with  $Es_2 = (Es\_jacket * Asl\_com\_jacket + Es\_core * Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00101015$   
 $shv = 0.00323248$   
 $ftv = 336.7189$   
 $fyv = 280.5991$   
 $suv = 0.00323248$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.18378198$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 280.5991$   
 with  $Es_v = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.07688397$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.07688397$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.04227683$   
 and confined core properties:  
 $b = 340.00$   
 $d = 327.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 34.17054$   
 $cc (5A.5, TBDY) = 0.00235471$   
 $c = \text{confinement factor} = 1.03547$   
 $1 = Asl\_ten / (b * d) * (fs_1 / fc) = 0.09875006$   
 $2 = Asl\_com / (b * d) * (fs_2 / fc) = 0.09875006$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.05430052$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.23357771$   
 $Mu = MRc (4.14) = 1.4747E+008$   
 $u = su (4.1) = 1.1814054E-005$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Lap Length:  $lb/ld = 0.18378198$   
 $lb = 300.00$   
 $ld = 1632.369$   
 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)  
 $= 1$   
 $db = 16.00$   
 Mean strength value of all re-bars:  $fy = 694.45$   
 Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 33.00$ , but  $fc'^{0.5} <= 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $t = 1.00$   
 $s = 0.80$   
 $e = 1.00$   
 $cb = 25.00$   
 $Ktr = 2.57611$   
 $Atr = Min(Atr_x, Atr_y) = 257.6106$   
 where  $Atr_x, Atr_y$  are the sum of the area of all stirrup legs along X and Y loxal axis  
 $s = Max(s\_external, s\_internal) = 250.00$

$$n = 16.00$$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 1.1814054E-005$$

$$\mu_{2+} = 1.4747E+008$$

with full section properties:

$$b = 400.00$$

$$d = 357.00$$

$$d' = 43.00$$

$$v = 0.0012789$$

$$N = 6026.684$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00951404$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.00951404$$

$$\mu_{we} \text{ (5.4c)} = 0.02260544$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.24250288$$

$$\mu_{ase1} = 0.24250288$$

$$b_{o\_1} = 340.00$$

$$h_{o\_1} = 340.00$$

$$b_{i2\_1} = 462400.00$$

$$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.24250288$$

$$b_{o\_2} = 192.00$$

$$h_{o\_2} = 192.00$$

$$b_{i2\_2} = 147456.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 3.07617$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.07617$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 3.07617$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00392699$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 400.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00050265$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 200.00$$

$$A_{sec} = 160000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \mu_{cc} = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y_1 = 0.00101015$$

$$sh_1 = 0.00323248$$

$$ft_1 = 336.7189$$

$$fy_1 = 280.5991$$

su1 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00101015

sh2 = 0.00323248

ft2 = 336.7189

fy2 = 280.5991

su2 = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00101015

shv = 0.00323248

ftv = 336.7189

fyv = 280.5991

suv = 0.00323248

using (30) in Biskinis/Fardis (2013) multiplied with 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 = 0.18378198

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 = 280.5991

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.07688397

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.07688397

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.04227683

and confined core properties:

b = 340.00

d = 327.00

d' = 13.00

fcc (5A.2, TBDY) = 34.17054

cc (5A.5, TBDY) = 0.00235471

c = confinement factor = 1.03547

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09875006

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09875006

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05430052

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.23357771

Mu = MRc (4.14) = 1.4747E+008

u = su (4.1) = 1.1814054E-005

Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$l_b = 300.00$

$d = 1632.369$

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)

$= 1$

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 694.45$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where  $A_{tr_x}, A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

Calculation of  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$\mu = 1.1814054E-005$

$\mu_u = 1.4747E+008$

with full section properties:

$b = 400.00$

$d = 357.00$

$d' = 43.00$

$v = 0.0012789$

$N = 6026.684$

$f_c = 33.00$

$c_o$  (5A.5, TBDY) = 0.002

Final value of  $\mu_u$ :  $\mu_u = \text{shear\_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.00951404$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_u = 0.00951404$

$w_e$  (5.4c) = 0.02260544

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.24250288$

$a_{se1} = 0.24250288$

$b_{o1} = 340.00$

$h_{o1} = 340.00$

$b_{i2,1} = 462400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.24250288$

$b_{o2} = 192.00$

$h_{o2} = 192.00$

$b_{i2,2} = 147456.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 3.07617$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$p_{sh1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00392699$

$A_{sh1} = A_{stir, 1} \cdot n_{s, 1} = 157.0796$

No stirrups,  $n_{s, 1} = 2.00$

$h_1 = 400.00$

$p_{sh2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00050265$

$A_{sh2} = A_{stir, 2} \cdot n_{s, 2} = 100.531$

No stirrups,  $n_{s, 2} = 2.00$

$h_2 = 200.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{sh2} \cdot F_{ywe2} = 3.07617$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00392699$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 400.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00050265$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 200.00$$

$$Asec = 160000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$y1 = 0.00101015$$

$$sh1 = 0.00323248$$

$$ft1 = 336.7189$$

$$fy1 = 280.5991$$

$$su1 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/ld = 0.18378198$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 280.5991$$

$$\text{with } Es1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.00101015$$

$$sh2 = 0.00323248$$

$$ft2 = 336.7189$$

$$fy2 = 280.5991$$

$$su2 = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/lb, \text{min} = 0.18378198$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

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.

$$y2, sh2, ft2, fy2, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 280.5991$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.00101015$$

$$shv = 0.00323248$$

$$ftv = 336.7189$$

$$fyv = 280.5991$$

$$suv = 0.00323248$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \text{min} = lb/ld = 0.18378198$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

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.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 280.5991$$

$$\text{with } Esv = (Es_{\text{jacket}} \cdot Asl, \text{mid, jacket} + Es_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.07688397$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.07688397$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.04227683$$

and confined core properties:

$$b = 340.00$$

$$d = 327.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 34.17054$$

$$c_c (5A.5, TBDY) = 0.00235471$$

$$c = \text{confinement factor} = 1.03547$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.09875006$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09875006$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05430052$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.23357771$$

$$\mu_u = M R_c (4.14) = 1.4747E+008$$

$$u = s_u (4.1) = 1.1814054E-005$$

-----  
Calculation of ratio  $l_b/d$

Lap Length:  $l_b/d = 0.18378198$

$$l_b = 300.00$$

$$d = 1632.369$$

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)

$$= 1$$

$$d_b = 16.00$$

$$\text{Mean strength value of all re-bars: } f_y = 694.45$$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$t = 1.00$$

$$s = 0.80$$

$$e = 1.00$$

$$c_b = 25.00$$

$$K_{tr} = 2.57611$$

$$A_{tr} = \text{Min}(A_{tr,x}, A_{tr,y}) = 257.6106$$

where  $A_{tr,x}$ ,  $A_{tr,y}$  are the sum of the area of all stirrup legs along X and Y local axis

$$s = \text{Max}(s_{external}, s_{internal}) = 250.00$$

$$n = 16.00$$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 463630.789$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 463630.789$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 463630.789$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

-----  
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:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8 * h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 279254.914$$

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

Calculation of Shear Strength at edge 2, Vr2 = 463630.789

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

$$VCol0 = 463630.789$$

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 = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 4.0970837E-012$$

$$V_u = 6.7333103E-047$$

$$d = 0.8*h = 320.00$$

$$N_u = 6026.684$$

$$A_g = 160000.00$$

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 279254.914

where:

Vs1 = 279254.914 is calculated for jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.3125$$

Vs2 = 0.00 is calculated for core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 1.5625$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 488465.275

$$bw = 400.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 400.00$

External Width,  $W = 400.00$

Internal Height,  $H = 200.00$

Internal Width,  $W = 200.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Lap Length  $l_b = 300.00$

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = 224.2544$

Shear Force,  $V_2 = 8151.474$

Shear Force,  $V_3 = 7.0895948E-013$

Axial Force,  $F = -6025.178$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1291.195$

-Compression:  $A_{sl,com} = 1291.195$

-Middle:  $A_{sl,mid} = 709.9999$

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:  $A_{sl,ten,core} = 461.8141$

-Compression:  $A_{sl,com,core} = 461.8141$

-Middle:  $A_{sl,mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement,  $DbL = 16.33333$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = 1.0^*$   $u = 0.0290557$

$u = \gamma + \rho = 0.0290557$

- Calculation of  $\gamma$  -

$\gamma = (My * Ls / 3) / E_{eff} = 0.00072782 ((4.29), Biskinis Phd)$

$My = 1.2577E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 300.00

From table 10.5, ASCE 41\_17:  $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.7280\text{E}+013$

factor = 0.30

$A_g = 160000.00$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$

$N = 6025.178$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 5.7599\text{E}+013$

Calculation of Yielding Moment  $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$

$y_{\text{ten}} = 5.2162547\text{E}-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (I_b/I_d)^{2/3}) = 260.4851$

$d = 357.00$

$y = 0.3005995$

$A = 0.02321793$

$B = 0.01307848$

with  $p_t = 0.00442965$

$p_c = 0.00904198$

$p_v = 0.00497199$

$N = 6025.178$

$b = 400.00$

" = 0.12044818

$y_{\text{comp}} = 2.0592195\text{E}-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.29926833$

$A = 0.02296005$

$B = 0.0129165$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Lap Length:  $I_d/I_{d,\text{min}} = 0.22972747$

$I_b = 300.00$

$I_d = 1305.895$

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

$d_b = 16.00$

Mean strength value of all re-bars:  $f_y = 555.56$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$t = 1.00$

$s = 0.80$

$e = 1.00$

$c_b = 25.00$

$K_{tr} = 2.57611$

$A_{tr} = \text{Min}(A_{tr_x}, A_{tr_y}) = 257.6106$

where  $A_{tr_x}$ ,  $A_{tr_y}$  are the sum of the area of all stirrup legs along X and Y local axis

$s = \text{Max}(s_{\text{external}}, s_{\text{internal}}) = 250.00$

$n = 16.00$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.02832787$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b/I_d < 1$

shear control ratio  $V_y E / V_{CoI} E = 0.21205453$

$d = d_{\text{external}} = 357.00$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00442965$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00392699$$

Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 400.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00050265$$

Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 200.00$$

$$s_2 = 250.00$$

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.

$$N_{UD} = 6025.178$$

$$A_g = 160000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot A_{\text{jacket}} + f_{c\_core} \cdot A_{\text{core}}) / \text{section\_area} = 33.00$$

$$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot A_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot A_{\text{int\_Long\_Reinf}}) / A_{\text{Tot\_Long\_Rein}} = 555.56$$

$$f_{yTE} = (f_{y\_ext\_Trans\_Reinf} \cdot A_{\text{ext\_Trans\_Reinf}} + f_{y\_int\_Trans\_Reinf} \cdot A_{\text{int\_Trans\_Reinf}}) / A_{\text{Tot\_Trans\_Rein}} = 555.56$$

$$p_l = A_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.02305595$$

$$b = 400.00$$

$$d = 357.00$$

$$f_{cE} = 33.00$$

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End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

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