

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

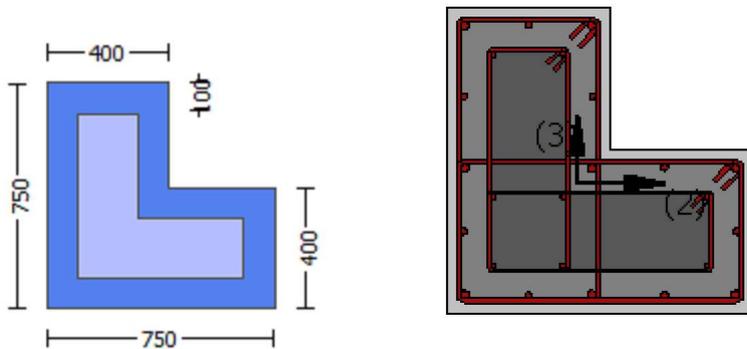
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
 Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of  $\mu_y$  for displacement ductility demand,  
 the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as  
 Deformation-Controlled Action (Table C7-1, ASCE 41-17).  
 Jacket  
 New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Existing Column  
 Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material: Steel Strength,  $f_s = f_{sm} = 444.4444$   
 #####  
 Max Height,  $H_{max} = 750.00$   
 Min Height,  $H_{min} = 400.00$   
 Max Width,  $W_{max} = 750.00$   
 Min Width,  $W_{min} = 400.00$   
 Jacket Thickness,  $t_j = 100.00$   
 Cover Thickness,  $c = 25.00$   
 Element Length,  $L = 3000.00$   
 Primary Member  
 Ribbed Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d >= 1$ )  
 No FRP Wrapping

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 Stepwise Properties  
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EDGE -A-  
 Bending Moment,  $M_a = -1.2625E+007$   
 Shear Force,  $V_a = -4191.702$   
 EDGE -B-  
 Bending Moment,  $M_b = 46459.419$   
 Shear Force,  $V_b = 4191.702$   
 BOTH EDGES  
 Axial Force,  $F = -16698.158$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl} = 0.00$   
 -Compression:  $A_{sl,c} = 5353.274$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl,ten} = 1137.257$   
 -Compression:  $A_{sl,com} = 2208.54$   
 -Middle:  $A_{sl,mid} = 2007.478$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$   
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 Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 876302.282$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 876302.282$   
 $V_{CoI} = 876302.282$   
 $k_n = 1.00$   
 $displacement\_ductility\_demand = 0.01193912$   
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NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = \phi \cdot V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).  
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$\phi = 1$  (normal-weight concrete)  
 Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area_{jacket} + f'_{c\_core} \cdot Area_{core}) / Area_{section} = 21.31818$ , but  $f'_c^{0.5} < =$

8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 1.2625E+007$$

$$V_u = 4191.702$$

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

$$N_u = 16698.158$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 793340.11$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$$

$V_{s,j1} = 251327.412$  is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$V_{s,j2} = 471238.898$  is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$$

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$V_{s,c2} = 70773.799$  is calculated for section flange core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 736127.561$$

$$b_w = 400.00$$

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

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

From analysis, chord rotation  $\theta = 5.1274439E-005$

$$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00429466 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 6.1989E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 \cdot L \text{ and } L_s < 2 \cdot L) = 3011.834$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.4491E+014$$

$$\text{factor} = 0.30$$

$$A_g = 440000.00$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} \cdot \text{Area}_{jacket} + f'_{c,core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 27.68182$$

$$N = 16698.158$$

$$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 4.8303E+014$$

Calculation of Yielding Moment  $M_y$

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

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

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

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

$y_{\text{ten}} = 4.6432325\text{E-}006$

with  $f_y = 529.9948$

$d = 707.00$

$y = 0.19276172$

$A = 0.01015517$

$B = 0.00446558$

with  $p_t = 0.00214476$

$p_c = 0.00416509$

$p_v = 0.00378591$

$N = 16698.158$

$b = 750.00$

" = 0.06082037

$y_{\text{comp}} = 1.6223186\text{E-}005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19181213$

$A = 0.01002419$

$B = 0.00440616$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19276172 < t/d$

Calculation of ratio  $l_b/d$

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

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

At local axis: 2

Integration Section: (a)

## Calculation No. 2

column C1, Floor 1

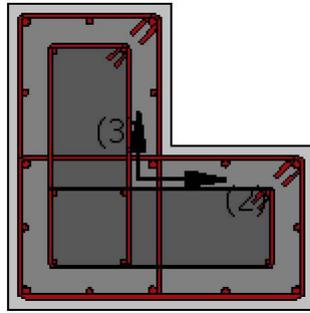
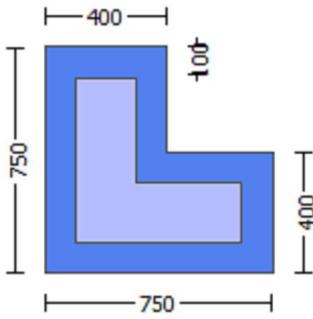
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $u$  )

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3  
 (Bending local axis: 2)  
 Section Type: rcjlcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

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Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

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

Existing Column

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

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Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, min} >= 1$ )

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{,com} = 2208.54$

-Middle:  $As_{,mid} = 2007.478$

Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.6649E+009$

$Mu_{1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6649E+009$

$Mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 5.0126992E-005$

$M_u = 1.0958E+009$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01155629$

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

From (5.4b), TBDY:  $\phi_u = 0.01155629$

$\omega_e (5.4c) = 0.04056485$

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

equal to half the clear spacing between external hoops.

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

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$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

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$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

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$A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$f_{ywe1} = 694.4444$   
 $f_{ywe2} = 555.5556$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 788.2136$   
 $fy1 = 656.8447$   
 $su1 = 0.032$

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

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

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

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

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

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

with  $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 798.4827$   
 $fy2 = 665.4022$   
 $su2 = 0.032$

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

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

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

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

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

with  $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 665.4022$

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

$yv = 0.0025$   
 $shv = 0.008$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

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

$$lo/lo_{u,min} = lb/d = 1.00$$

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 662.4935$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04269004$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.08398367$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

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

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04845844$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.09533179$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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$v < vs_{y2}$  - LHS eq.(4.5) is satisfied

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$$su (4.9) = 0.09705994$$

$$Mu = MRc (4.14) = 1.0958E+009$$

$$u = su (4.1) = 5.0126992E-005$$

Calculation of ratio  $lb/d$

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

Calculation of  $Mu1$ -

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

$$u = 6.3581565E-005$$

$$Mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01155629$$

$$we (5.4c) = 0.04056485$$

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.  
 $A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase2 (>=ase1) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2})*(A_{conf,min2}/A_{conf,max2}),0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.  
 $A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min}*Fywe = \text{Min}(psh_x*Fywe, psh_y*Fywe) = 2.92621$

---

$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

---

$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

---

$Asec = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.4444$

$fywe2 = 555.5556$

$fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c =$  confinement factor = 1.22693

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 798.4827$

$fy1 = 665.4022$

$su1 = 0.032$

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

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

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

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

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

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

with  $fs1 = (fs_{jacket}*Asl_{ten,jacket} + fs_{core}*Asl_{ten,core})/Asl_{ten} = 665.4022$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$$f_y2 = 656.8447$$

$$s_u2 = 0.032$$

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

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

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

From table 5A.1, TBDY:  $e_{s_u2,nominal} = 0.08$ ,

For calculation of  $e_{s_u2,nominal}$  and  $y_2, sh_2, ft_2, f_y2$ , it is considered  
characteristic value  $f_{s_y2} = f_{s_2}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_y1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_2} = (f_{s,jacket} * A_{s_l,com,jacket} + f_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 656.8447$$

$$\text{with } E_{s_2} = (E_{s,jacket} * A_{s_l,com,jacket} + E_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$f_{t_v} = 794.9922$$

$$f_{y_v} = 662.4935$$

$$s_{u_v} = 0.032$$

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

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

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

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

considering characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{s_{u_v},nominal}$  and  $y_v, sh_v, f_{t_v}, f_{y_v}$ , it is considered  
characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, f_y1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_v} = (f_{s,jacket} * A_{s_l,mid,jacket} + f_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 662.4935$$

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

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.15746938$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.08004382$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

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

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.19346746$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.09834213$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is not satisfied

--->

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

--->

$$s_u (4.8) = 0.28813219$$

$$\mu_u = M_{Rc} (4.15) = 1.6649E+009$$

$$u = s_u (4.1) = 6.3581565E-005$$

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

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

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

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

$$u = 5.0126992E-005$$

$$\mu = 1.0958E+009$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

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

equal to half the clear spacing between external hoops.

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

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

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

equal to half the clear spacing between internal hoops.

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00426926$$

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

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 798.4827$$

$$fy2 = 665.4022$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 665.4022$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.04269004$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08398367$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.04845844$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09533179$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$su (4.9) = 0.09705994$$

$$Mu = MRc (4.14) = 1.0958E+009$$

$$u = s_u(4.1) = 5.0126992E-005$$

Calculation of ratio  $l_b/d$

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

Calculation of  $\mu_2$

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

$$u = 6.3581565E-005$$

$$\mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e(5.4c) = 0.04056485$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) = Lstir2\*Astir2/(Asec\*s2) = 0.00067082  
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
Asec = 440000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

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

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

$d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19346746$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09834213$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17508576$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

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

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

--->  
 $s_u (4.8) = 0.28813219$   
 $\mu = MR_c (4.15) = 1.6649E+009$   
 $u = s_u (4.1) = 6.3581565E-005$

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

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

-----  
 Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

-----  
 Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$   
 $V_{Col0} = 998292.205$   
 $k_{nl} = 1$  (zero step-static loading)

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

-----  
 $= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 4.00$   
 $\mu = 13.31807$   
 $V_u = 0.00051441$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16273.616$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$   
 where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$

$V_{s,j1}$  is multiplied by  $Col_{j1} = 1.00$   
 $s/d = 0.16666667$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$

$V_{s,j2}$  is multiplied by  $Col_{j2} = 1.00$   
 $s/d = 0.3125$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 78637.555$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$

$f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$   
 $s/d = 0.56818182$   
 $V_{s,c2} = 0.00$  is calculated for section flange core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

-----  
 Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

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

$V_{Col0} = 998292.205$

$kn1 = 1$  (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:  $f'_c = (f'_c\_jacket * Area\_jacket + f'_c\_core * Area\_core) / Area\_section = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31753$

$V_u = 0.00051441$

$d = 0.8 * h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

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

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

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 0.56818182$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcjcs

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

#### Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten = 1137.257$   
-Compression:  $Asl,com = 2208.54$   
-Middle:  $Asl,mid = 2007.478$

Calculation of Shear Capacity ratio ,  $Ve/Vr = 1.11182$

Member Controlled by Shear ( $Ve/Vr > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $Ve = (Mpr1 + Mpr2)/ln = 1.1099E+006$   
with

$Mpr1 = \text{Max}(Mu1+, Mu1-) = 1.6649E+009$

$Mu1+ = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu1- = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu2+, Mu2-) = 1.6649E+009$

$Mu2+ = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu2- = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu1+$

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

$\phi_u = 5.0126992E-005$

$Mu = 1.0958E+009$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$fc = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01155629$

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

From (5.4b), TBDY:  $\phi_u = 0.01155629$

$\phi_{ue}$  (5.4c) = 0.04056485

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 788.2136  
fy1 = 656.8447  
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4 \* esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket \* Asl,ten,jacket + fs,core \* Asl,ten,core) / Asl,ten = 656.8447

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 798.4827  
fy2 = 665.4022  
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket \* Asl,com,jacket + fs,core \* Asl,com,core) / Asl,com = 665.4022

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

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

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

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

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

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

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

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

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04269004$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.08398367$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04845844$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09533179$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.09705994$$

$$M_u = M_{Rc} (4.14) = 1.0958E+009$$

$$u = s_u (4.1) = 5.0126992E-005$$

Calculation of ratio  $l_b/l_d$

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

Calculation of  $M_{u1}$ -

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

$$u = 6.3581565E-005$$

$$M_u = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_{cc}) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } \phi_c = 0.01155629$$

$$\phi_{cc} (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $bi^2/6$  as defined at (A.2).  
ase2 ( $\geq$  ase1) =  $\text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $bi^2/6$  as defined at (A.2).  
psh,min\*Fywe =  $\text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.92621$

psh\_x\*Fywe =  $psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
psh1 ((5.4d), TBDY) =  $Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 (5.4d) =  $Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y\*Fywe =  $psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
psh1 ((5.4d), TBDY) =  $Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 =  $(fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 665.4022$

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

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

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

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

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

$$\text{with } fs_2 = (fs_{jacket} * Asl_{,com,jacket} + fs_{core} * Asl_{,com,core}) / Asl_{,com} = 656.8447$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fs_v = (fs_{jacket} * Asl_{,mid,jacket} + fs_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 662.4935$$

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

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.15746938$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.08004382$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

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

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.19346746$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.09834213$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$$su (4.8) = 0.28813219$$

$$Mu = MRc (4.15) = 1.6649E+009$$

$$u = su (4.1) = 6.3581565E-005$$

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

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

-----  
Calculation of  $Mu_{2+}$

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

$$u = 5.0126992E-005$$

$$Mu = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$fc = 33.00$$

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

$$\text{Final value of } cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01155629$$

$$we (5.4c) = 0.04056485$$

$$ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $b_i/6$  as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i/6$  as defined at (A.2).

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.92621$$

$$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621$$

$$psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709$$

$$Lstir1 (\text{Length of stirrups along Y}) = 2060.00$$

$$Astir1 (\text{stirrups area}) = 78.53982$$

$$psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082$$

$$Lstir2 (\text{Length of stirrups along Y}) = 1468.00$$

$$Astir2 (\text{stirrups area}) = 50.26548$$

$$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621$$

$$psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709$$

$$Lstir1 (\text{Length of stirrups along X}) = 2060.00$$

$$Astir1 (\text{stirrups area}) = 78.53982$$

$$psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082$$

$$Lstir2 (\text{Length of stirrups along X}) = 1468.00$$

$$Astir2 (\text{stirrups area}) = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00426926$$

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

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

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

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

Shear\_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

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

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.

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 656.8447$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 798.4827$$

$$fy_2 = 665.4022$$

$$s_u2 = 0.032$$

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

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

Shear\_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_{b,min} = 1.00$$

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

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.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 665.4022$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$s_uv = 0.032$$

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

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

Shear\_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

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

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

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , 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.

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04269004$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.08398367$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04845844$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09533179$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.09705994$$

$$\mu = M_{Rc} (4.14) = 1.0958E+009$$

$$u = s_u (4.1) = 5.0126992E-005$$

Calculation of ratio  $l_b/l_d$

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

Calculation of Mu2-

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

$$\mu = 6.3581565E-005$$

$$\mu_u = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \alpha) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.01155629$$

$$\mu_{we} (5.4c) = 0.04056485$$

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

$$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$$\alpha_{se2} (>= \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

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

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

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938  
2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382  
v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00  
d = 677.00  
d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.09834213$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

---->

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

---->

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

---->

$$s_u(4.8) = 0.28813219$$

$$M_u = M_{Rc}(4.15) = 1.6649E+009$$

$$u = s_u(4.1) = 6.3581565E-005$$

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

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

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

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

$$V_{Col0} = 998292.205$$

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

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

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

Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$M_u = 13.32441$$

$$V_u = 0.00051441$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16273.616$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

$V_{s,j1} = 279252.68$  is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

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

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

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

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

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

$$V_{Col0} = 998292.205$$

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

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$M_u = 13.32496$$

$$V_u = 0.00051441$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16273.616$$

$$A_g = 300000.00$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{sjacket} + V_{s,core} = 881489.011$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 279252.68$  is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$V_{sj2} = 523598.776$  is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

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

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

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 1.5625$$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

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

$$s/d = 0.56818182$$

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

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$$b_w = 400.00$$

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

At local axis: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcjlc

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_b/l_d >= 1$ )

No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -157932.678$

Shear Force,  $V_2 = -4191.702$

Shear Force,  $V_3 = 76.96362$

Axial Force,  $F = -16698.158$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $A_{st,com} = 2208.54$

-Middle:  $A_{st,mid} = 2007.478$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten,jacket} = 829.3805$

-Compression:  $A_{st,com,jacket} = 1746.726$

-Middle:  $A_{st,mid,jacket} = 1545.664$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten,core} = 307.8761$

-Compression:  $A_{st,com,core} = 461.8141$

-Middle:  $A_{st,mid,core} = 461.8141$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = * u = 0.00515616$

$$u = y + p = 0.00515616$$

- Calculation of  $y$  -

$$y = (M_y * L_s / 3) / E_{eff} = 0.00292607 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 6.1989E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 2052.043$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.4491E+014$$

$$\text{factor} = 0.30$$

$$A_g = 440000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 27.68182$$

$$N = 16698.158$$

$$E_c * I_g = E_{c_{\text{jacket}}} * I_{g_{\text{jacket}}} + E_{c_{\text{core}}} * I_{g_{\text{core}}} = 4.8303E+014$$

Calculation of Yielding Moment  $M_y$

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

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

$$\text{flange width, } b = 750.00$$

$$\text{web width, } b_w = 400.00$$

$$\text{flange thickness, } t = 400.00$$

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

$$y_{\text{ten}} = 4.6432325E-006$$

$$\text{with } f_y = 529.9948$$

$$d = 707.00$$

$$y = 0.19276172$$

$$A = 0.01015517$$

$$B = 0.00446558$$

$$\text{with } p_t = 0.00434791$$

$$p_c = 0.00416509$$

$$p_v = 0.00378591$$

$$N = 16698.158$$

$$b = 750.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.6223186E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.19181213$$

$$A = 0.01002419$$

$$B = 0.00440616$$

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

CONFIRMATION:  $y = 0.19276172 < t/d$

Calculation of ratio  $l_b/d$

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

- Calculation of  $p$  -

From table 10-8:  $p = 0.00223009$

with:

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

$$\text{shear control ratio } V_y E / V_{CoI} O E = 1.11182$$

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

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

$$- t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$$

$$\text{jacket: } s_1 = A_{v1} * L_{\text{stir1}} / (s_1 * A_g) = 0.00367709$$

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

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

core:  $s_2 = A_{v2} \cdot L_{stir2} / (s_2 \cdot A_g) = 0.00067082$

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

$L_{stir2} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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

where  $f = 2 \cdot t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

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

For the normalisation  $f_s$  of jacket is used.

$NUD = 16698.158$

$A_g = 440000.00$

$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 27.68182$

$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 529.9948$

$f_{yIE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$

$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.01009575$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

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

At local axis: 2

Integration Section: (a)

### Calculation No. 3

column C1, Floor 1

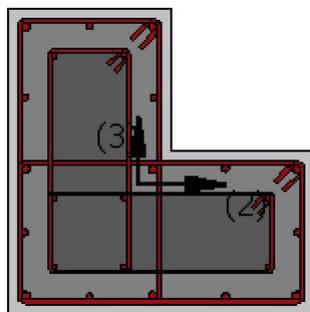
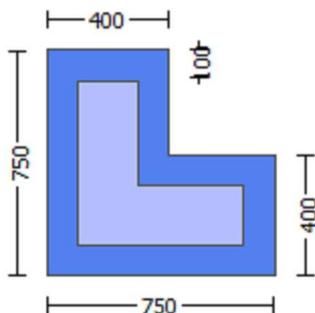
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcjics

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

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

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

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -157932.678$

Shear Force,  $V_a = 76.96362$

EDGE -B-

Bending Moment,  $M_b = -71780.379$

Shear Force,  $V_b = -76.96362$

BOTH EDGES

Axial Force,  $F = -16698.158$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

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

-Compression:  $A_{sl,c} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $A_{sl,com} = 2208.54$

-Middle:  $A_{sl,mid} = 2007.478$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 900071.137$

$V_n$  ((10.3), ASCE 41-17) =  $k_n I^* V_{CoIO} = 900071.137$

$V_{CoI} = 900071.137$

$k_n I = 1.00$

$displacement\_ductility\_demand = 0.00686044$

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

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c\_jacket} * Area\_jacket + f'_{c\_core} * Area\_core) / Area\_section = 21.31818$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 3.42007$

$M_u = 157932.678$

$V_u = 76.96362$

$d = 0.8 * h = 600.00$

$N_u = 16698.158$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 793340.11$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$

$V_{s,j1} = 471238.898$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.16666667$

$V_{s,j2} = 251327.412$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.3125$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$

$V_{s,c1} = 70773.799$  is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

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

$s/d = 0.56818182$

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 400.00$

$s = 250.00$

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

$s/d = 1.5625$

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

From (11-11), ACI 440:  $V_s + V_f \leq 736127.561$

$bw = 400.00$

$displacement\_ductility\_demand$  is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END A -

for rotation axis 2 and integ. section (a)

From analysis, chord rotation  $\theta = 2.0074119E-005$

$y = (M_y * L_s / 3) / E_{eff} = 0.00292607$  ((4.29), Biskinis Phd)

$M_y = 6.1989E+008$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2052.043

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$

$factor = 0.30$

$$A_g = 440000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$$

$$N = 16698.158$$

$$E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 4.8303E+014$$

Calculation of Yielding Moment  $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

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

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

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

$$y_{\text{ten}} = 4.6432325E-006$$

with  $f_y = 529.9948$

$$d = 707.00$$

$$y = 0.19276172$$

$$A = 0.01015517$$

$$B = 0.00446558$$

$$\text{with } p_t = 0.00214476$$

$$p_c = 0.00416509$$

$$p_v = 0.00378591$$

$$N = 16698.158$$

$$b = 750.00$$

$$\rho = 0.06082037$$

$$y_{\text{comp}} = 1.6223186E-005$$

with  $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.19181213$$

$$A = 0.01002419$$

$$B = 0.00440616$$

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

CONFIRMATION:  $y = 0.19276172 < t/d$

Calculation of ratio  $l_b/d$

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

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

At local axis: 3

Integration Section: (a)

## Calculation No. 4

column C1, Floor 1

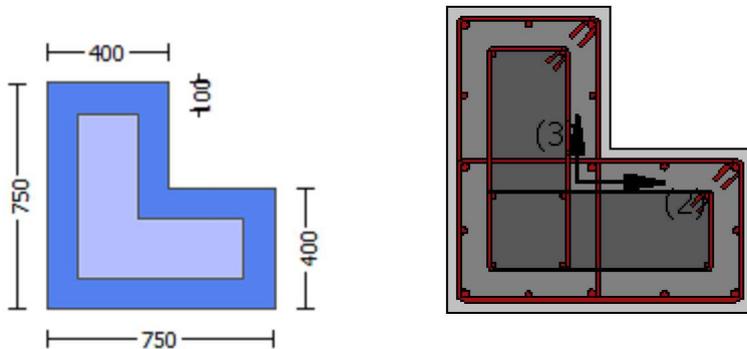
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjlcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )  
No FRP Wrapping

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

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -0.00051441$   
EDGE -B-  
Shear Force,  $V_b = 0.00051441$   
BOTH EDGES  
Axial Force,  $F = -16273.616$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{c,com} = 2208.54$   
-Middle:  $As_{c,mid} = 2007.478$   
-----  
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.11182$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with  
 $M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.6649E+009$   
 $\mu_{1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $\mu_{1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.6649E+009$   
 $\mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $\mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $\mu_{1+}$   
-----  
-----

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

$$\mu = 5.0126992E-005$$

$$M_u = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.01155629$$

$$\mu_{cc} (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization  
of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.  
 $A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noconf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noconf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noconf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

$A_{noconf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

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

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

$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

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

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

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

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

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

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

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

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

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

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

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

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

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

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

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

For calculation of  $e_{su1,nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

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

with  $f_{s1} = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 656.8447$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 798.4827$

$fy2 = 665.4022$

$su2 = 0.032$

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

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

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04845844

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09533179

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08627414

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

su (4.9) = 0.09705994

Mu = MRc (4.14) = 1.0958E+009

u = su (4.1) = 5.0126992E-005

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length: lb/ld >= 1  
-----  
-----

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

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

u = 6.3581565E-005

Mu = 1.6649E+009  
-----

with full section properties:

b = 400.00

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$$a_{se2} (> a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00426926$$

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 798.4827$$

$$fy_1 = 665.4022$$

$$su_1 = 0.032$$

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

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

Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

Shear\_factor = 1.00

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

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

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

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

Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

Calculation of ratio  $l_b/d$

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

Calculation of  $\mu_{2+}$

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

$$\mu = 5.0126992E-005$$

$$\mu_{2+} = 1.0958E+009$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{2+}: \mu_{2+}^* = \text{shear\_factor} * \text{Max}(\mu_{2+}, c_c) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } \mu_{2+} = 0.01155629$$

$$\mu_{2+} \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 788.2136  
fy1 = 656.8447  
su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 798.4827  
fy2 = 665.4022  
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

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

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

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

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

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

b = 690.00  
d = 677.00  
d' = 13.00

$f_{cc}$  (5A.2, TBDY) = 40.48856  
 $c_c$  (5A.5, TBDY) = 0.00426926  
 $c$  = confinement factor = 1.22693  
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04845844$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09533179$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08627414$   
 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) = 0.09705994  
 $\mu_u = MR_c$  (4.14) = 1.0958E+009  
 $u = s_u$  (4.1) = 5.0126992E-005

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

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

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

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

$u = 6.3581565E-005$   
 $\mu_u = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$   
 $f_c = 33.00$

$c_o$  (5A.5, TBDY) = 0.002  
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.01155629$

$w_e$  (5.4c) = 0.04056485  
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$   
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).  
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."  
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.  
 $A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.  
 $A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$   
 The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."  
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.  
 $A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.  
 $A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.  
 $A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 2.92621$$

$$psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 \text{ (Length of stirrups along X)} = 2060.00$$

$$Astir1 \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 \text{ (Length of stirrups along X)} = 1468.00$$

$$Astir2 \text{ (stirrups area)} = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00426926$$

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

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 798.4827$$

$$fy1 = 665.4022$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 665.4022$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 656.8447$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$su_v = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 662.4935$$

$$\text{with } Esv = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$$

$$1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.15746938$$

$$2 = Asl\_com / (b * d) * (fs2 / fc) = 0.08004382$$

$$v = Asl\_mid / (b * d) * (fsv / fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

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

$$1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.19346746$$

$$2 = Asl\_com / (b * d) * (fs2 / fc) = 0.09834213$$

$$v = Asl\_mid / (b * d) * (fsv / fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is not satisfied

--->

$v < vs,c$  - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.28813219$$

$$Mu = MRc (4.15) = 1.6649E+009$$

$$u = su (4.1) = 6.3581565E-005$$

Calculation of ratio  $lb/ld$

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

Calculation of Shear Strength  $Vr = Min(Vr1, Vr2) = 998292.205$

Calculation of Shear Strength at edge 1,  $Vr1 = 998292.205$

$Vr1 = VCol ((10.3), ASCE 41-17) = knl * VColO$

$$VColO = 998292.205$$

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

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).

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

Mean concrete strength:  $fc' = (fc'_jacket * Area\_jacket + fc'_core * Area\_core) / Area\_section = 27.68182$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$Mu = 13.31807$$

$$Vu = 0.00051441$$

$$d = 0.8 * h = 600.00$$

$$Nu = 16273.616$$

$$Ag = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } Vs = Vs\_jacket + Vs\_core = 881489.011$$

where:

$$Vs\_jacket = Vs\_j1 + Vs\_j2 = 802851.456$$

$Vs\_j1 = 523598.776$  is calculated for section web jacket, with:

$$d = 600.00$$

$$Av = 157079.633$$

$$fy = 555.5556$$

$$s = 100.00$$

$V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 78637.555$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$   
 $s/d = 0.56818182$   
 $V_{s,c2} = 0.00$  is calculated for section flange core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 998292.205$   
 $knl = 1$  (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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/d = 4.00$   
 $\mu_u = 13.31753$   
 $V_u = 0.00051441$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16273.616$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$   
 where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 523598.776$  is calculated for section web jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 78637.555$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$

fy = 444.4444  
s = 250.00  
Vs,c1 is multiplied by Col,c1 = 1.00  
s/d = 0.56818182  
Vs,c2 = 0.00 is calculated for section flange core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.4444  
s = 250.00  
Vs,c2 is multiplied by Col,c2 = 0.00  
s/d = 1.5625  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 838832.606  
bw = 400.00

-----  
-----  
End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcjics

Constant Properties

-----  
Knowledge Factor, = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength, fc = fcm = 33.00  
New material of Primary Member: Steel Strength, fs = fsm = 555.5556  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00  
Existing Column  
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00  
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444  
Concrete Elasticity, Ec = 21019.039  
Steel Elasticity, Es = 200000.00  
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength, fs = 1.25\*fsm = 694.4444  
Existing Column  
Existing material: Steel Strength, fs = 1.25\*fsm = 555.5556  
#####  
Max Height, Hmax = 750.00  
Min Height, Hmin = 400.00  
Max Width, Wmax = 750.00  
Min Width, Wmin = 400.00  
Jacket Thickness, tj = 100.00  
Cover Thickness, c = 25.00  
Mean Confinement Factor overall section = 1.22693  
Element Length, L = 3000.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length (lo/lo,min >= 1)  
No FRP Wrapping

## Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $A_{sc,com} = 2208.54$

-Middle:  $A_{st,mid} = 2007.478$

Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.6649E+009$

$Mu_{1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6649E+009$

$Mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 5.0126992E-005$

$M_u = 1.0958E+009$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$f_c = 33.00$

$\alpha_1(5A.5, \text{TBDY}) = 0.002$

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01155629$

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

From (5.4b), TBDY:  $\phi_u = 0.01155629$

$\omega_e$  (5.4c) =  $0.04056485$

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

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

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

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $b_i/6$  as defined at (A.2).  
 $ase2 (>=ase1) = \text{Max}(((Aconf,max2-AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2),0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i/6$  as defined at (A.2).  
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.92621$

-----  
 $psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621$   
 $psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2 (5.4d) = Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
 $psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 2.92621$   
 $psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
Asec = 440000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 788.2136  
fy1 = 656.8447  
su1 = 0.032

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

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fsjacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 798.4827  
fy2 = 665.4022  
su2 = 0.032

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

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

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

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

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

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

with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 665.4022$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$s_{uv} = 0.032$

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

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

$s_{uv} = 0.4 \cdot es_{uv\_nominal} ((5.5), TBDY) = 0.032$

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

considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY

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

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

with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 662.4935$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04269004$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.08398367$

$v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.07600422$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 40.48856

$cc$  (5A.5, TBDY) = 0.00426926

$c$  = confinement factor = 1.22693

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04845844$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09533179$

$v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.08627414$

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) = 0.09705994

$\mu_u = MR_c$  (4.14) = 1.0958E+009

$u = s_u$  (4.1) = 5.0126992E-005

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

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

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

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

$u = 6.3581565E-005$

$\mu_u = 1.6649E+009$

-----  
with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174378$

$N = 16273.616$

$fc = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$

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

From (5.4b), TBDY:  $c_u = 0.01155629$

$w_e$  (5.4c) = 0.04056485

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

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

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

$p_{sh2}$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

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

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

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

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

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

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

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

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

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00426926$

$c$  = confinement factor = 1.22693

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 798.4827$

$fy1 = 665.4022$

$su1 = 0.032$

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

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

Shear\_factor = 1.00

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

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

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

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

characteristic value  $f_{sy1} = f_{s1}/1.2$ , 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  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 665.4022$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 788.2136$

$fy_2 = 656.8447$

$su_2 = 0.032$

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

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

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{d,min} = 1.00$

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

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

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered

characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 656.8447$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$su_v = 0.032$

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

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

Shear\_factor = 1.00

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

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

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

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

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 662.4935$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15746938$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08004382$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.14250792$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.48856$

$cc (5A.5, TBDY) = 0.00426926$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.19346746$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09834213$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

---->

$su (4.8) = 0.28813219$

$Mu = MRc (4.15) = 1.6649E+009$

$u = su (4.1) = 6.3581565E-005$

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

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

-----  
-----

Calculation of  $\mu_{2+}$

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

$$\mu = 5.0126992E-005$$

$$\mu = 1.0958E+009$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.01155629$$

$$\mu_{cc} (5.4c) = 0.04056485$$

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

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

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.4444$$

$$fy_{we2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00426926$

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 656.8447$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 798.4827$$

$$fy_2 = 665.4022$$

$$su_2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_2 = (fs_{\text{jacket}} * Asl, \text{com, jacket} + fs_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 665.4022$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$suv = 0.032$$

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

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

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

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

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

$$\text{with } fsv = (fs_{\text{jacket}} * Asl, \text{mid, jacket} + fs_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 662.4935$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.04269004$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.08398367$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TBDY}) = 40.48856$$

$$cc (5A.5, \text{TBDY}) = 0.00426926$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.04845844$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.09533179$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.08627414$$

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) = 0.09705994  
 $\mu_u$  = MRc (4.14) = 1.0958E+009  
 $u$  =  $s_u$  (4.1) = 5.0126992E-005

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

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

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

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

$u$  = 6.3581565E-005  
 $\mu_u$  = 1.6649E+009

-----  
with full section properties:

$b$  = 400.00  
 $d$  = 707.00  
 $d'$  = 43.00  
 $v$  = 0.00174378  
 $N$  = 16273.616  
 $f_c$  = 33.00  
 $\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01155629$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\alpha_c = 0.01155629$

$w_e$  (5.4c) = 0.04056485

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

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

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

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

psh2 (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y \* Fywe = psh1 \* Fywe1 + ps2 \* Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 798.4827

fy1 = 665.4022

su1 = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

with fs1 =  $(fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

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

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

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

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

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

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

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

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

with fs2 =  $(fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$

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

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

with  $f_{sv} = (f_s \cdot j_{\text{jacket}} \cdot A_{s, \text{mid, jacket}} + f_s \cdot \text{mid} \cdot A_{s, \text{mid, core}}) / A_{s, \text{mid}} = 662.4935$   
 with  $E_{sv} = (E_s \cdot j_{\text{jacket}} \cdot A_{s, \text{mid, jacket}} + E_s \cdot \text{mid} \cdot A_{s, \text{mid, core}}) / A_{s, \text{mid}} = 200000.00$   
 $1 = A_{s, \text{ten}} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15746938$   
 $2 = A_{s, \text{com}} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08004382$   
 $v = A_{s, \text{mid}} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14250792$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} \text{ (5A.2, TBDY)} = 40.48856$   
 $cc \text{ (5A.5, TBDY)} = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{s, \text{ten}} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.19346746$   
 $2 = A_{s, \text{com}} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09834213$   
 $v = A_{s, \text{mid}} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

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

--->

$su \text{ (4.8)} = 0.28813219$

$Mu = MRc \text{ (4.15)} = 1.6649E+009$

$u = su \text{ (4.1)} = 6.3581565E-005$

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

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

-----  
 Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$   
 -----

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

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

$V_{\text{Col}0} = 998292.205$

$k_{nl} = 1$  (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:  $f'_c = (f'_c \cdot j_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 4.00$

$Mu = 13.32441$

$Vu = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$Nu = 16273.616$

$Ag = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s, \text{jacket}} + V_{s, \text{core}} = 881489.011$

where:

$V_{s, \text{jacket}} = V_{s, j1} + V_{s, j2} = 802851.456$

$V_{s, j1} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

$V_{s, j2} = 523598.776$  is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 0.00$   
 $s/d = 1.5625$   
 $V_{s,c2} = 78637.555$  is calculated for section flange core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

-----  
 Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

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

$V_{Col0} = 998292.205$

$knl = 1$  (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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.32496$

$\nu_u = 0.00051441$

$d = 0.8 * h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.3125$

$V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

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

$s/d = 0.16666667$

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

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

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

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

$s/d = 1.5625$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$d = 440.00$

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c2 is multiplied by Col,c2 = 1.00

s/d = 0.56818182

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

From (11-11), ACI 440: Vs + Vf <= 838832.606

bw = 400.00

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

At local axis: 2

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

At local axis: 3

Integration Section: (a)

Section Type: rcjics

Constant Properties

-----  
Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

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

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

Max Height, Hmax = 750.00

Min Height, Hmin = 400.00

Max Width, Wmax = 750.00

Min Width, Wmin = 400.00

Jacket Thickness, tj = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lb/ld >= 1)

No FRP Wrapping

-----  
Stepwise Properties

Bending Moment, M = -1.2625E+007

Shear Force, V2 = -4191.702

Shear Force, V3 = 76.96362

Axial Force, F = -16698.158

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00

-Compression: Asc = 5353.274

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1137.257

-Compression: Asl,com = 2208.54

-Middle: Asl,mid = 2007.478

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten,jacket = 829.3805$

-Compression:  $Asl,com,jacket = 1746.726$

-Middle:  $Asl,mid,jacket = 1545.664$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl,ten,core = 307.8761$

-Compression:  $Asl,com,core = 461.8141$

-Middle:  $Asl,mid,core = 461.8141$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u,R = * u = 0.00652475$   
 $u = y + p = 0.00652475$

- Calculation of  $y$  -

$y = (My*Ls/3)/Eleff = 0.00429466$  ((4.29),Biskinis Phd))

$My = 6.1989E+008$

$Ls = M/V$  (with  $Ls > 0.1*L$  and  $Ls < 2*L$ ) = 3011.834

From table 10.5, ASCE 41\_17:  $Eleff = factor*Ec*Ig = 1.4491E+014$

factor = 0.30

$Ag = 440000.00$

Mean concrete strength:  $fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 27.68182$

$N = 16698.158$

$Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 4.8303E+014$

Calculation of Yielding Moment  $My$

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

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

flange width,  $b = 750.00$

web width,  $bw = 400.00$

flange thickness,  $t = 400.00$

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

$y_{ten} = 4.6432325E-006$

with  $fy = 529.9948$

$d = 707.00$

$y = 0.19276172$

$A = 0.01015517$

$B = 0.00446558$

with  $pt = 0.00434791$

$pc = 0.00416509$

$pv = 0.00378591$

$N = 16698.158$

$b = 750.00$

" = 0.06082037

$y_{comp} = 1.6223186E-005$

with  $fc = 33.00$

$Ec = 26999.444$

$y = 0.19181213$

$A = 0.01002419$

$B = 0.00440616$

with  $Es = 200000.00$

CONFIRMATION:  $y = 0.19276172 < t/d$

Calculation of ratio  $lb/d$

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

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.00223009$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/l_d \geq 1$   
shear control ratio  $V_{yE}/V_{Col0E} = 1.11182$

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

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

-  $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00434791$

$$\text{jacket: } s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$$

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

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$$

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

$L_{\text{stir2}} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

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.

$$N_{UD} = 16698.158$$

$$A_g = 440000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot \text{Area\_jacket} + f_{c\_core} \cdot \text{Area\_core}) / \text{section\_area} = 27.68182$$

$$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot \text{Area\_ext\_Long\_Reinf} + f_{y\_int\_Long\_Reinf} \cdot \text{Area\_int\_Long\_Reinf}) / \text{Area\_Tot\_Long\_Rein} = 529.9948$$

$$f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$$

$$\rho = \text{Area\_Tot\_Long\_Rein} / (b \cdot d) = 0.01009575$$

$$b = 750.00$$

$$d = 707.00$$

$$f_{cE} = 27.68182$$

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

At local axis: 3

Integration Section: (a)

## Calculation No. 5

column C1, Floor 1

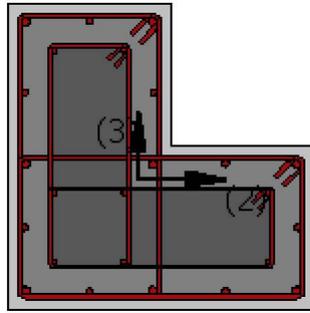
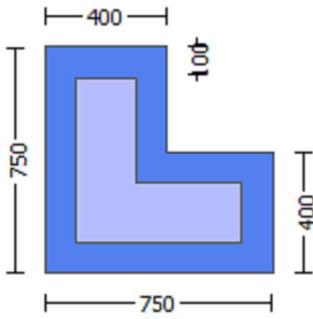
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcjlcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

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

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

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -1.2625E+007$

Shear Force,  $V_a = -4191.702$   
EDGE -B-  
Bending Moment,  $M_b = 46459.419$   
Shear Force,  $V_b = 4191.702$   
BOTH EDGES  
Axial Force,  $F = -16698.158$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 2208.54$   
-Middle:  $A_{st,mid} = 2007.478$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 1.0165E+006$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 1.0165E+006$   
 $V_{CoI} = 1.0165E+006$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.03075436

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

= 1 (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 21.31818$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$   
 $M_u = 46459.419$   
 $V_u = 4191.702$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16698.158$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 793340.11$   
where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$   
 $V_{s,j1} = 251327.412$  is calculated for section web jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$

$V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,j2} = 471238.898$  is calculated for section flange jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$

$V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$

$V_{s,c1}$  is multiplied by  $Col,c1 = 0.00$   
 $s/d = 1.5625$   
 $V_{s,c2} = 70773.799$  is calculated for section flange core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 1.00$

s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 736127.561  
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 = 1.3156056E-005  
y = (My\*Ls/3)/Eleff = 0.00042778 ((4.29),Biskinis Phd))  
My = 6.1989E+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 = 1.4491E+014  
factor = 0.30  
Ag = 440000.00  
Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 27.68182  
N = 16698.158  
Ec\*Ig = Ec\_jacket\*Ig\_jacket + Ec\_core\*Ig\_core = 4.8303E+014

-----  
Calculation of Yielding Moment My

-----  
Calculation of y and My according to Annex 7 -

-----  
Assuming neutral axis within flange ( y < t/d, compression zone rectangular) with:  
flange width, b = 750.00  
web width, bw = 400.00  
flange thickness, t = 400.00

-----  
y = Min( y\_ten, y\_com)  
y\_ten = 4.6432325E-006  
with fy = 529.9948  
d = 707.00  
y = 0.19276172  
A = 0.01015517  
B = 0.00446558  
with pt = 0.00214476  
pc = 0.00416509  
pv = 0.00378591  
N = 16698.158  
b = 750.00  
" = 0.06082037  
y\_comp = 1.6223186E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.19181213  
A = 0.01002419  
B = 0.00440616  
with Es = 200000.00  
CONFIRMATION: y = 0.19276172 < t/d

-----  
Calculation of ratio lb/d

-----  
Adequate Lap Length: lb/d >= 1

-----  
End Of Calculation of Shear Capacity for element: column JLC1 of floor 1  
At local axis: 2  
Integration Section: (b)

## Calculation No. 6

column C1, Floor 1

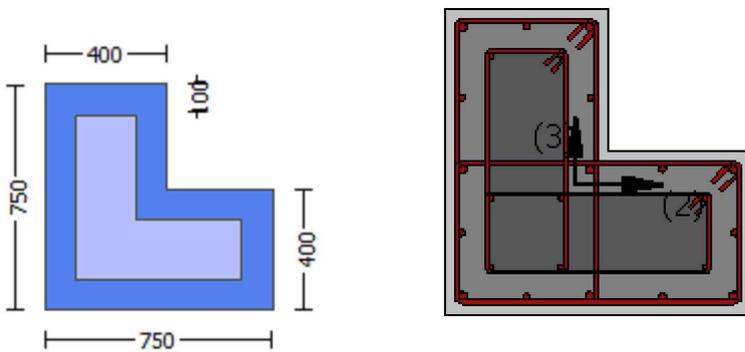
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\theta$  )

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$   
Min Width,  $W_{min} = 400.00$   
Jacket Thickness,  $t_j = 100.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.22693  
Element Length,  $L = 3000.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou,min} \geq 1$ )  
No FRP Wrapping

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

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -0.00051441$   
EDGE -B-  
Shear Force,  $V_b = 0.00051441$   
BOTH EDGES  
Axial Force,  $F = -16273.616$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{l,com} = 2208.54$   
-Middle:  $As_{l,mid} = 2007.478$

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Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.6649E+009$   
 $Mu_{1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $Mu_{1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6649E+009$   
 $Mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $Mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

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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:  
 $\phi_u = 5.0126992E-005$   
 $Mu = 1.0958E+009$

-----  
with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093001$   
 $N = 16273.616$   
 $f_c = 33.00$   
 $\omega$  (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$

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

From (5.4b), TBDY:  $c_u = 0.01155629$

$w_e$  (5.4c) = 0.04056485

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

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

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

$p_{sh2}$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

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

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

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

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

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

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

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

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

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00426926$

$c$  = confinement factor = 1.22693

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

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

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

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

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

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

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

characteristic value  $f_{sy1} = f_{s1}/1.2$ , 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  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 656.8447$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 798.4827$

$fy_2 = 665.4022$

$su_2 = 0.032$

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

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

Shear\_factor = 1.00

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

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

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

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered

characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 665.4022$

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

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$su_v = 0.032$

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

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

Shear\_factor = 1.00

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

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

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

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

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 662.4935$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04269004$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08398367$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.07600422$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.48856$

$cc (5A.5, TBDY) = 0.00426926$

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

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.04845844$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09533179$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

$su (4.9) = 0.09705994$

$Mu = MRc (4.14) = 1.0958E+009$

$u = su (4.1) = 5.0126992E-005$

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

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

-----  
Calculation of  $Mu_1$ -

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

$$u = 6.3581565E-005$$

$$\mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01155629$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01155629$$

$$\phi_{we}(5.4c) = 0.04056485$$

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

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

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

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

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

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.92621$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

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

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

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

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

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

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

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

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

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

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

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00426926$

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 798.4827$$

$$fy_1 = 665.4022$$

$$su_1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$su_2 = 0.032$$

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

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

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

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.

$$\text{with } fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 662.4935$$

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

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.15746938$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.08004382$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

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

$$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.19346746$$

$$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.09834213$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $s_u(4.8) = 0.28813219$   
 $\mu_u = M_{Rc}(4.15) = 1.6649E+009$   
 $u = s_u(4.1) = 6.3581565E-005$

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

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

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

-----  
 Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 5.0126992E-005$   
 $\mu_u = 1.0958E+009$   
 -----

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093001$   
 $N = 16273.616$   
 $f_c = 33.00$   
 $\alpha(5A.5, TBDY) = 0.002$

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\mu_u = 0.01155629$

$w_e(5.4c) = 0.04056485$

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

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

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

$\alpha_{se2} (\geq \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

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

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

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

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1}(5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

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

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

psh2 (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y \* Fywe = psh1 \* Fywe1 + ps2 \* Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 =  $(fs\_jacket * A_{sl,ten,jacket} + fs\_core * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$

with Es1 =  $(Es\_jacket * A_{sl,ten,jacket} + Es\_core * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $Min(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(fs\_jacket * A_{sl,com,jacket} + fs\_core * A_{sl,com,core}) / A_{sl,com} = 665.4022$

with Es2 =  $(Es\_jacket * A_{sl,com,jacket} + Es\_core * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv =  $0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv, ftv, fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $Min(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 662.4935$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04269004$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08398367$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07600422$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04845844$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09533179$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.09705994$   
 $\mu_u = MR_c (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $l_b/d$

-----  
 Adequate Lap Length:  $l_b/d \geq 1$   
 -----  
 -----

-----  
 Calculation of  $\mu_{u2}$ -  
 -----  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$   
 $\mu_u = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$   
 $f_c = 33.00$

$co (5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.01155629$

we (5.4c)  $= 0.04056485$

$ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.4444$   
 $fywe2 = 555.5556$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 798.4827$   
 $fy1 = 665.4022$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

with  $Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 788.2136$   
 $fy2 = 656.8447$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$

with  $Es2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length: lb/ld >= 1

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 998292.205

-----  
Calculation of Shear Strength at edge 1, Vr1 = 998292.205

Vr1 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 998292.205

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 = 27.68182, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/d = 4.00

Mu = 13.31807

Vu = 0.00051441

d = 0.8\*h = 600.00

Nu = 16273.616

$A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$   
 where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 523598.776$  is calculated for section web jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 78637.555$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$   
 $s/d = 0.56818182$   
 $V_{s,c2} = 0.00$  is calculated for section flange core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$   
 $V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_{nl} * V_{Col0}$   
 $V_{Col0} = 998292.205$   
 $k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 13.31753$   
 $V_u = 0.00051441$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16273.616$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$   
 where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 523598.776$  is calculated for section web jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:  
 $d = 320.00$

Av = 157079.633

fy = 555.5556

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.3125

Vs,core = Vs,c1 + Vs,c2 = 78637.555

Vs,c1 = 78637.555 is calculated for section web core, with:

d = 440.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c1 is multiplied by Col,c1 = 1.00

s/d = 0.56818182

Vs,c2 = 0.00 is calculated for section flange core, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c2 is multiplied by Col,c2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 838832.606

bw = 400.00

-----  
End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 3

-----  
Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjls

Constant Properties

-----  
Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25\*fsm = 694.4444

Existing Column

Existing material: Steel Strength, fs = 1.25\*fsm = 555.5556

#####

Max Height, Hmax = 750.00

Min Height, Hmin = 400.00

Max Width, Wmax = 750.00

Min Width, Wmin = 400.00

Jacket Thickness, tj = 100.00

Cover Thickness, c = 25.00

Mean Confinement Factor overall section = 1.22693

Element Length, L = 3000.00

Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou, \min} >= 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -0.00051441$   
EDGE -B-  
Shear Force,  $V_b = 0.00051441$   
BOTH EDGES  
Axial Force,  $F = -16273.616$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl} = 0.00$   
-Compression:  $A_{sc} = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl, \text{ten}} = 1137.257$   
-Compression:  $A_{sl, \text{com}} = 2208.54$   
-Middle:  $A_{sl, \text{mid}} = 2007.478$

-----  
-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.11182$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with  
 $M_{pr1} = \text{Max}(\mu_{u1+} , \mu_{u1-}) = 1.6649E+009$   
 $\mu_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $\mu_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{u2+} , \mu_{u2-}) = 1.6649E+009$   
 $\mu_{u2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $\mu_{u2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $\mu_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 5.0126992E-005$   
 $\mu_u = 1.0958E+009$

-----  
with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093001$   
 $N = 16273.616$   
 $f_c = 33.00$   
 $\omega (5A.5, \text{TBDY}) = 0.002$   
Final value of  $\omega$ :  $\omega^* = \text{shear\_factor} * \text{Max}(\omega_u, \omega_c) = 0.01155629$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\omega_u = 0.01155629$   
 $\omega_w (5.4c) = 0.04056485$   
 $\omega_{ase} ((5.4d), \text{TBDY}) = (\omega_{ase1} * A_{ext} + \omega_{ase2} * A_{int}) / A_{sec} = 0.45746528$   
 $\omega_{ase1} = \text{Max}(((A_{conf, \text{max}1} - A_{noConf1}) / A_{conf, \text{max}1}) * (A_{conf, \text{min}1} / A_{conf, \text{max}1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$lo/lou_{min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 656.8447$

with  $Es1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$$ft2 = 798.4827$$

$$fy2 = 665.4022$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/lb_{u,min} = 1.00$$

$$su2 = 0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 665.4022$$

$$\text{with } Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 662.4935$$

$$\text{with } Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.04269004$$

$$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.08398367$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{sl,ten} / (b * d) * (fs1 / fc) = 0.04845844$$

$$2 = A_{sl,com} / (b * d) * (fs2 / fc) = 0.09533179$$

$$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$  - LHS eq.(4.5) is satisfied

---->

$$su (4.9) = 0.09705994$$

$$Mu = MRc (4.14) = 1.0958E+009$$

$$u = su (4.1) = 5.0126992E-005$$

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$   
-----  
-----

-----  
Calculation of  $Mu1$ -  
-----

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$Mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 798.4827$$

$$fy1 = 665.4022$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$su1 = 0.4*esu1\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 665.4022$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15746938$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08004382$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.19346746$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09834213$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

$$su (4.8) = 0.28813219$$

$$\begin{aligned} \text{Mu} &= \text{MRc (4.15)} = 1.6649\text{E}+009 \\ u &= \text{su (4.1)} = 6.3581565\text{E}-005 \end{aligned}$$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\text{Mu}_{2+}$

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$\begin{aligned} u &= 5.0126992\text{E}-005 \\ \text{Mu} &= 1.0958\text{E}+009 \end{aligned}$$

with full section properties:

$$\begin{aligned} b &= 750.00 \\ d &= 707.00 \\ d' &= 43.00 \\ v &= 0.00093001 \\ N &= 16273.616 \\ f_c &= 33.00 \end{aligned}$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) = Lstir2\*Astir2/(Asec\*s2) = 0.00067082  
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
Asec = 440000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 788.2136  
fy1 = 656.8447  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 798.4827  
fy2 = 665.4022  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04845844$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09533179$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08627414$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.09705994$   
 $Mu = MRc (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $l_b/d$

-----  
 Adequate Lap Length:  $l_b/d \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu_2$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$   
 $Mu = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$

$f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01155629$

$we (5.4c) = 0.04056485$   
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.45746528$   
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$AnoConf2 = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
     $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
     $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
     $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
     $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
     $L_{stir1}$  (Length of stirrups along X) = 2060.00  
     $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
     $L_{stir2}$  (Length of stirrups along X) = 1468.00  
     $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $f_{ywe1} = 694.4444$   
 $f_{ywe2} = 555.5556$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 798.4827$   
 $fy1 = 665.4022$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 788.2136$   
 $fy2 = 656.8447$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$

with  $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 794.9922$   
 $fyv = 662.4935$   
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su = 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 = (fsjacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

-----  
Calculation of ratio lb/d

-----  
Adequate Lap Length: lb/d >= 1

-----  
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 998292.205

-----  
Calculation of Shear Strength at edge 1, Vr1 = 998292.205

Vr1 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 998292.205

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 = 27.68182, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 13.32441

Vu = 0.00051441

d = 0.8\*h = 600.00

Nu = 16273.616

Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 881489.011

where:

Vs,jacket = Vs,j1 + Vs,j2 = 802851.456

Vs,j1 = 279252.68 is calculated for section web jacket, with:

d = 320.00

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V<sub>s,j1</sub> is multiplied by Col<sub>j1</sub> = 1.00

$$s/d = 0.3125$$

V<sub>s,j2</sub> = 523598.776 is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V<sub>s,j2</sub> is multiplied by Col<sub>j2</sub> = 1.00

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

V<sub>s,c1</sub> = 0.00 is calculated for section web core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V<sub>s,c1</sub> is multiplied by Col<sub>c1</sub> = 0.00

$$s/d = 1.5625$$

V<sub>s,c2</sub> = 78637.555 is calculated for section flange core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

V<sub>s,c2</sub> is multiplied by Col<sub>c2</sub> = 1.00

$$s/d = 0.56818182$$

$$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 838832.606$$

$$b_w = 400.00$$

Calculation of Shear Strength at edge 2, V<sub>r2</sub> = 998292.205

$$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$$

$$V_{Col0} = 998292.205$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

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).

$$= 1 \text{ (normal-weight concrete)}$$

$$\text{Mean concrete strength: } f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 4.00$$

$$\mu_u = 13.32496$$

$$\nu_u = 0.00051441$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16273.616$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

V<sub>s,j1</sub> = 279252.68 is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V<sub>s,j1</sub> is multiplied by Col<sub>j1</sub> = 1.00

$$s/d = 0.3125$$

V<sub>s,j2</sub> = 523598.776 is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

V<sub>s,j2</sub> is multiplied by Col<sub>j2</sub> = 1.00

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

V<sub>s,c1</sub> = 0.00 is calculated for section web core, with:

d = 160.00

A<sub>v</sub> = 100530.965

f<sub>y</sub> = 444.4444

s = 250.00

V<sub>s,c1</sub> is multiplied by Col,c1 = 0.00

s/d = 1.5625

V<sub>s,c2</sub> = 78637.555 is calculated for section flange core, with:

d = 440.00

A<sub>v</sub> = 100530.965

f<sub>y</sub> = 444.4444

s = 250.00

V<sub>s,c2</sub> is multiplied by Col,c2 = 1.00

s/d = 0.56818182

V<sub>f</sub> ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: V<sub>s</sub> + V<sub>f</sub> <= 838832.606

bw = 400.00

-----  
End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 2

-----  
Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjics

Constant Properties

-----  
Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, f<sub>c</sub> = f<sub>cm</sub> = 33.00

New material of Primary Member: Steel Strength, f<sub>s</sub> = f<sub>sm</sub> = 555.5556

Concrete Elasticity, E<sub>c</sub> = 26999.444

Steel Elasticity, E<sub>s</sub> = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, f<sub>c</sub> = f<sub>cm</sub> = 20.00

Existing material of Primary Member: Steel Strength, f<sub>s</sub> = f<sub>sm</sub> = 444.4444

Concrete Elasticity, E<sub>c</sub> = 21019.039

Steel Elasticity, E<sub>s</sub> = 200000.00

Max Height, H<sub>max</sub> = 750.00

Min Height, H<sub>min</sub> = 400.00

Max Width, W<sub>max</sub> = 750.00

Min Width, W<sub>min</sub> = 400.00

Jacket Thickness, t<sub>j</sub> = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (l<sub>b</sub>/l<sub>d</sub> >= 1)

No FRP Wrapping

-----  
Stepwise Properties

Bending Moment, M = -71780.379

Shear Force, V<sub>2</sub> = 4191.702

Shear Force, V<sub>3</sub> = -76.96362

Axial Force,  $F = -16698.158$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $As_t = 0.00$   
 -Compression:  $As_c = 5353.274$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $As_{ten} = 1137.257$   
 -Compression:  $As_{com} = 2208.54$   
 -Middle:  $As_{mid} = 2007.478$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $As_{ten,jacket} = 829.3805$   
 -Compression:  $As_{com,jacket} = 1746.726$   
 -Middle:  $As_{mid,jacket} = 1545.664$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $As_{ten,core} = 307.8761$   
 -Compression:  $As_{com,core} = 461.8141$   
 -Middle:  $As_{mid,core} = 461.8141$   
 Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = \rho \cdot u = 0.00355999$   
 $u = y + p = 0.00355999$

- Calculation of  $y$  -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.0013299$  ((4.29), Biskinis Phd)  
 $M_y = 6.1989E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 932.6534  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.4491E+014$   
 $factor = 0.30$   
 $A_g = 440000.00$   
 Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$   
 $N = 16698.158$   
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:  
 flange width,  $b = 750.00$   
 web width,  $b_w = 400.00$   
 flange thickness,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 4.6432325E-006$   
 with  $f_y = 529.9948$   
 $d = 707.00$   
 $y = 0.19276172$   
 $A = 0.01015517$   
 $B = 0.00446558$   
 with  $p_t = 0.00434791$   
 $p_c = 0.00416509$   
 $p_v = 0.00378591$   
 $N = 16698.158$   
 $b = 750.00$   
 $\rho = 0.06082037$   
 $y_{comp} = 1.6223186E-005$   
 with  $fc = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19181213$   
 $A = 0.01002419$   
 $B = 0.00440616$

with  $E_s = 200000.00$   
CONFIRMATION:  $y = 0.19276172 < t/d$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00223009$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/l_d \geq 1$   
shear control ratio  $V_y E / V_{CoI} E = 1.11182$

$d = d_{\text{external}} = 707.00$

$s = s_{\text{external}} = 0.00$

-  $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00434791$

jacket:  $s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$

$A_{v2} = 50.26548$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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.

$N_{UD} = 16698.158$

$A_g = 440000.00$

$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 27.68182$

$f_{yE} = (f_{y_{\text{ext\_Long\_Reinf}}} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 529.9948$

$f_{yE} = (f_{y_{\text{ext\_Trans\_Reinf}}} \cdot s_1 + f_{y_{\text{int\_Trans\_Reinf}}} \cdot s_2) / (s_1 + s_2) = 538.4128$

$p_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01009575$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (b)

**Calculation No. 7**

column C1, Floor 1

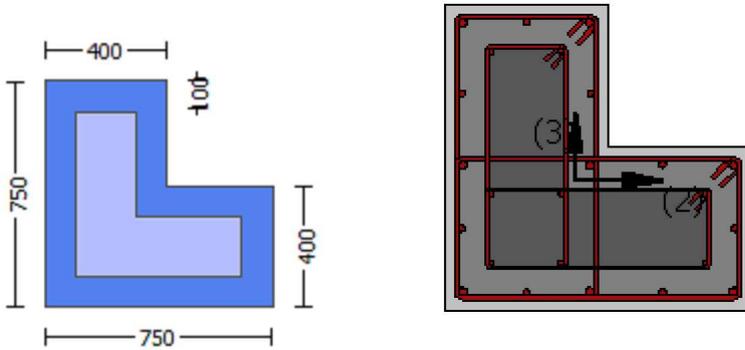
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjlcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.4444$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou}, \min = l_b/l_d \geq 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

EDGE -A-  
Bending Moment,  $M_a = -157932.678$   
Shear Force,  $V_a = 76.96362$   
EDGE -B-  
Bending Moment,  $M_b = -71780.379$   
Shear Force,  $V_b = -76.96362$   
BOTH EDGES  
Axial Force,  $F = -16698.158$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{st,com} = 2208.54$   
-Middle:  $A_{st,mid} = 2007.478$   
Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = *V_n = 1.0165E+006$   
 $V_n ((10.3), ASCE 41-17) = knl * V_{CoI0} = 1.0165E+006$   
 $V_{CoI} = 1.0165E+006$   
 $knl = 1.00$   
 $displacement\_ductility\_demand = 2.2864413E-005$

-----  
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_{c\_jacket} * Area\_jacket + f'_{c\_core} * Area\_core) / Area\_section = 21.31818$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 71780.379$   
 $V_u = 76.96362$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16698.158$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{sjacket} + V_{s,core} = 793340.11$   
where:  
 $V_{sjacket} = V_{sj1} + V_{sj2} = 722566.31$   
 $V_{sj1} = 471238.898$  is calculated for section web jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{sj1}$  is multiplied by  $Col_{j1} = 1.00$   
 $s/d = 0.16666667$   
 $V_{sj2} = 251327.412$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{sj2}$  is multiplied by  $Col_{j2} = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$

$V_{s,c1} = 70773.799$  is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

$V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

$V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$

$$s/d = 1.5625$$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 736127.561$

$$b_w = 400.00$$

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  $= 3.0407312E-008$

$$y = (M_y * L_s / 3) / E_{eff} = 0.0013299 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 6.1989E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 932.6534$$

From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 1.4491E+014$

$$\text{factor} = 0.30$$

$$A_g = 440000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 27.68182$$

$$N = 16698.158$$

$$E_c * I_g = E_c * I_{g_{\text{jacket}}} + E_c * I_{g_{\text{core}}} = 4.8303E+014$$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi / y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 4.6432325E-006$$

with  $f_y = 529.9948$

$$d = 707.00$$

$$y = 0.19276172$$

$$A = 0.01015517$$

$$B = 0.00446558$$

with  $p_t = 0.00214476$

$$p_c = 0.00416509$$

$$p_v = 0.00378591$$

$$N = 16698.158$$

$$b = 750.00$$

$$" = 0.06082037$$

$$y_{\text{comp}} = 1.6223186E-005$$

with  $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.19181213$$

$$A = 0.01002419$$

$$B = 0.00440616$$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19276172 < t/d$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

## Calculation No. 8

column C1, Floor 1

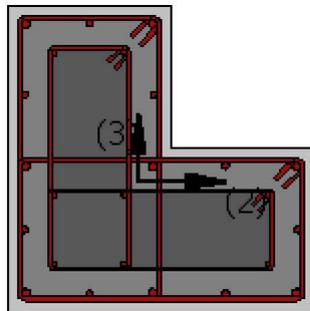
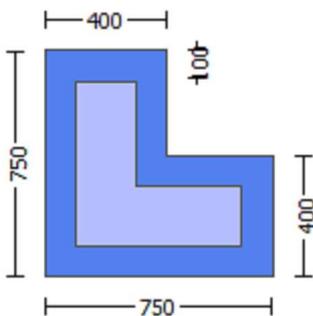
Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjics

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.4444$   
Existing Column  
Existing material: Steel Strength,  $f_s = 1.25 * f_{sm} = 555.5556$   
#####  
Max Height,  $H_{max} = 750.00$   
Min Height,  $H_{min} = 400.00$   
Max Width,  $W_{max} = 750.00$   
Min Width,  $W_{min} = 400.00$   
Jacket Thickness,  $t_j = 100.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.22693  
Element Length,  $L = 3000.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou,min} >= 1$ )  
No FRP Wrapping

-----

Stepwise Properties

-----

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -0.00051441$   
EDGE -B-  
Shear Force,  $V_b = 0.00051441$   
BOTH EDGES  
Axial Force,  $F = -16273.616$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{,ten} = 1137.257$   
-Compression:  $As_{,com} = 2208.54$   
-Middle:  $As_{,mid} = 2007.478$

-----

-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.11182$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.6649E+009$   
 $Mu_{1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $Mu_{1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.6649E+009$   
 $Mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination  
 $Mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----

Calculation of  $Mu_{1+}$

-----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 5.0126992E-005$$

$$Mu = 1.0958E+009$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01155629$$

$$we \text{ (5.4c)} = 0.04056485$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 2.92621$$

$$psh_{,x} * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$psh_{,y} * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00426926$$

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04845844

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09533179

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08627414

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.09705994$$

$$\mu = M_{Rc}(4.14) = 1.0958E+009$$

$$u = s_u(4.1) = 5.0126992E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $\mu_1$ -

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu = 1.6649E+009$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e(5.4c) = 0.04056485$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1}(\text{Length of stirrups along } Y) = 2060.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2}(\text{Length of stirrups along } Y) = 1468.00$$

$$A_{stir2}(\text{stirrups area}) = 50.26548$$
  
-----

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 2.92621  
psh<sub>1</sub> ((5.4d), TBDY) = Lstir<sub>1</sub>\*Astir<sub>1</sub>/(Asec\*s<sub>1</sub>) = 0.00367709  
Lstir<sub>1</sub> (Length of stirrups along X) = 2060.00  
Astir<sub>1</sub> (stirrups area) = 78.53982  
psh<sub>2</sub> ((5.4d), TBDY) = Lstir<sub>2</sub>\*Astir<sub>2</sub>/(Asec\*s<sub>2</sub>) = 0.00067082  
Lstir<sub>2</sub> (Length of stirrups along X) = 1468.00  
Astir<sub>2</sub> (stirrups area) = 50.26548

Asec = 440000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.4444

fywe<sub>2</sub> = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y<sub>1</sub> = 0.0025

sh<sub>1</sub> = 0.008

ft<sub>1</sub> = 798.4827

fy<sub>1</sub> = 665.4022

su<sub>1</sub> = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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/d)<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> = 665.4022

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> = 0.0025

sh<sub>2</sub> = 0.008

ft<sub>2</sub> = 788.2136

fy<sub>2</sub> = 656.8447

su<sub>2</sub> = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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/d)<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> = 656.8447

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> = 0.0025

sh<sub>v</sub> = 0.008

ft<sub>v</sub> = 794.9922

fy<sub>v</sub> = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv<sub>nominal</sub> ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv<sub>nominal</sub> = 0.08,

considering characteristic value fsyv = 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 fsyv = fsv/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/d)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fsv = (fs<sub>jacket</sub>\*Asl<sub>mid,jacket</sub> + fs<sub>mid</sub>\*Asl<sub>mid,core</sub>)/Asl<sub>mid</sub> = 662.4935

with Es<sub>v</sub> = (Es<sub>jacket</sub>\*Asl<sub>mid,jacket</sub> + Es<sub>mid</sub>\*Asl<sub>mid,core</sub>)/Asl<sub>mid</sub> = 200000.00

1 = Asl<sub>ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.15746938

2 = Asl<sub>com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.08004382

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.14250792$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.19346746$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09834213$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.17508576$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->  
 $\mu_u (4.8) = 0.28813219$   
 $\mu_u = M/R_c (4.15) = 1.6649E+009$   
 $u = \mu_u (4.1) = 6.3581565E-005$

-----  
 Calculation of ratio  $l_b/d$

-----  
 Adequate Lap Length:  $l_b/d \geq 1$

-----  
 Calculation of  $\mu_{u2+}$

-----  
 Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 5.0126992E-005$   
 $\mu_u = 1.0958E+009$

-----  
 with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093001$   
 $N = 16273.616$   
 $f_c = 33.00$   
 $cc (5A.5, TBDY) = 0.002$

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, cc) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\mu_u = 0.01155629$

$w_e (5.4c) = 0.04056485$   
 $a_{se} ((5.4d), TBDY) = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.45746528$   
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$   
 The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).  
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."  
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.  
 $A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.  
 $A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.  
 $A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$   
 The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).  
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

---

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

---

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

---

$A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$f_{ywe1} = 694.4444$   
 $f_{ywe2} = 555.5556$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 788.2136$   
 $fy1 = 656.8447$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$

with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 798.4827$   
 $fy2 = 665.4022$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 665.4022$

with  $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$   
 $shv = 0.008$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/d = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 662.4935$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04269004$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.08398367$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.04845844$$

$$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.09533179$$

$$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.09705994$$

$$Mu = MRc (4.14) = 1.0958E+009$$

$$u = su (4.1) = 5.0126992E-005$$

Calculation of ratio  $lb/d$

Adequate Lap Length:  $lb/d \geq 1$

Calculation of  $Mu2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$Mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01155629$$

$$we (5.4c) = 0.04056485$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 798.4827$

$fy1 = 665.4022$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o / l_{ou,min} = l_b / l_d = 1.00$

$su1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered

characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 665.4022$

with  $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15746938$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08004382$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.19346746$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09834213$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is not satisfied

--->

$v < vs,c$  - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.28813219$$

$$Mu = MRc (4.15) = 1.6649E+009$$

$$u = su (4.1) = 6.3581565E-005$$

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length:  $lb/ld \geq 1$   
-----  
-----  
-----

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr1,Vr2) = 998292.205$   
-----

Calculation of Shear Strength at edge 1,  $Vr1 = 998292.205$

$$Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO$$

$$VColO = 998292.205$$

$k_{nl} = 1$  (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:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31807$

$V_u = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $Col_{j1} = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $Col_{j2} = 1.00$

$s/d = 0.3125$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $Col_{c1} = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $Col_{c2} = 0.00$

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_{nl} \cdot V_{Col0}$

$V_{Col0} = 998292.205$

$k_{nl} = 1$  (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:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31753$

$V_u = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$   
 where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 523598.776$  is calculated for section web jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 78637.555$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$   
 $s/d = 0.56818182$   
 $V_{s,c2} = 0.00$  is calculated for section flange core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

-----  
 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
 At local axis: 3  
 -----

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
 At Shear local axis: 2  
 (Bending local axis: 3)  
 Section Type: rcjlc

Constant Properties

-----  
 Knowledge Factor,  $= 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$

#####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} > 1$ )

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 2

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 0.00$

-Compression:  $A_{sl,c} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 2208.54$

-Middle:  $A_{sl,mid} = 2007.478$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6649E+009$

$M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6649E+009$

$M_{u2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 5.0126992E-005$

$M_u = 1.0958E+009$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i d_i / 6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i d_i / 6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along } Y) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } X) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along } X) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04845844

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09533179

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08627414

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.09705994

Mu = MRc (4.14) = 1.0958E+009

u = su (4.1) = 5.0126992E-005

Calculation of ratio lb/d

Adequate Lap Length:  $lb/d \geq 1$

Calculation of  $\mu_1$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 6.3581565E-005$$

$$\mu_1 = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 798.4827

fy1 = 665.4022

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

$$cc \text{ (5A.5, TBDY)} = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.19346746$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09834213$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->  
v < vs,y2 - LHS eq.(4.5) is not satisfied

--->  
v < vs,c - RHS eq.(4.5) is satisfied

$$su \text{ (4.8)} = 0.28813219$$

$$Mu = MRc \text{ (4.15)} = 1.6649E+009$$

$$u = su \text{ (4.1)} = 6.3581565E-005$$

-----  
Calculation of ratio lb/d

-----  
Adequate Lap Length: lb/d >= 1

-----  
Calculation of Mu2+

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 5.0126992E-005$$

$$Mu = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$fc = 33.00$$

$$co \text{ (5A.5, TBDY)} = 0.002$$

Final value of cu:  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $cu = 0.01155629$

$$we \text{ (5.4c)} = 0.04056485$$

$$ase \text{ ((5.4d), TBDY)} = (ase1*Aext+ase2*Aint)/Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $bi^2/6$  as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$   
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2 (5.4d) = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$   
 $psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 788.2136  
fy1 = 656.8447  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4 \* esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket \* Asl,ten,jacket + fs,core \* Asl,ten,core) / Asl,ten = 656.8447

with Es1 = (Es,jacket \* Asl,ten,jacket + Es,core \* Asl,ten,core) / Asl,ten = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 798.4827  
fy2 = 665.4022  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4 \* esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket \* Asl,com,jacket + fs,core \* Asl,com,core) / Asl,com = 665.4022

with Es2 = (Es,jacket \* Asl,com,jacket + Es,core \* Asl,com,core) / Asl,com = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $\gamma_v$ ,  $sh_v, ft_v, fy_v$ , it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$$\gamma_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 662.4935$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04269004$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.08398367$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.04845844$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09533179$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.09705994$$

$$\mu_u = M_{Rc} (4.14) = 1.0958E+009$$

$$u = s_u (4.1) = 5.0126992E-005$$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\mu_u$ -

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu_u = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase_2 (>=ase_1) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2})*(A_{conf,min2}/A_{conf,max2}),0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min}*F_{ywe} = \text{Min}(psh_x*F_{ywe}, psh_y*F_{ywe}) = 2.92621$

-----  
 $psh_x*F_{ywe} = psh_1*F_{ywe1} + ps_2*F_{ywe2} = 2.92621$   
 $psh_1$  ((5.4d), TBDY) =  $L_{stir1}*A_{stir1}/(A_{sec}*s_1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh_2$  (5.4d) =  $L_{stir2}*A_{stir2}/(A_{sec}*s_2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y*F_{ywe} = psh_1*F_{ywe1} + ps_2*F_{ywe2} = 2.92621$   
 $psh_1$  ((5.4d), TBDY) =  $L_{stir1}*A_{stir1}/(A_{sec}*s_1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh_2$  ((5.4d), TBDY) =  $L_{stir2}*A_{stir2}/(A_{sec}*s_2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$

$f_{ywe1} = 694.4444$   
 $f_{ywe2} = 555.5556$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$   
 $c =$  confinement factor = 1.22693

$y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 798.4827$   
 $fy_1 = 665.4022$   
 $su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su_1 = 0.4*es_{u1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $es_{u1,nominal} = 0.08$ ,

For calculation of  $es_{u1,nominal}$  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  $fs_1 = (f_{s,jacket}*A_{s1,ten,jacket} + f_{s,core}*A_{s1,ten,core})/A_{s1,ten} = 665.4022$

with  $Es_1 = (E_{s,jacket}*A_{s1,ten,jacket} + E_{s,core}*A_{s1,ten,core})/A_{s1,ten} = 200000.00$

$y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 788.2136$   
 $fy_2 = 656.8447$   
 $su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

$$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,

For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 656.8447$$

$$\text{with } Es_2 = (Es_{jacket} \cdot Asl_{,com,jacket} + Es_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_v = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 662.4935$$

$$\text{with } Es_v = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$$

$$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.15746938$$

$$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.08004382$$

$$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.19346746$$

$$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09834213$$

$$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$su (4.8) = 0.28813219$$

$$Mu = MRc (4.15) = 1.6649E+009$$

$$u = su (4.1) = 6.3581565E-005$$

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$$

$$V_{Col0} = 998292.205$$

$$knl = 1 \text{ (zero step-static loading)}$$

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$   
 $\mu_u = 13.32441$   
 $V_u = 0.00051441$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16273.616$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s\text{jacket}} + V_{s\text{core}} = 881489.011$   
where:  
 $V_{s\text{jacket}} = V_{s\text{j1}} + V_{s\text{j2}} = 802851.456$   
 $V_{s\text{j1}} = 279252.68$  is calculated for section web jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s\text{j1}}$  is multiplied by  $\text{Col,j1} = 1.00$   
 $s/d = 0.3125$   
 $V_{s\text{j2}} = 523598.776$  is calculated for section flange jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s\text{j2}}$  is multiplied by  $\text{Col,j2} = 1.00$   
 $s/d = 0.16666667$   
 $V_{s\text{core}} = V_{s\text{c1}} + V_{s\text{c2}} = 78637.555$   
 $V_{s\text{c1}} = 0.00$  is calculated for section web core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s\text{c1}}$  is multiplied by  $\text{Col,c1} = 0.00$   
 $s/d = 1.5625$   
 $V_{s\text{c2}} = 78637.555$  is calculated for section flange core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s\text{c2}}$  is multiplied by  $\text{Col,c2} = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $b_w = 400.00$

-----  
Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col0}}$

$V_{\text{Col0}} = 998292.205$

$k_{nl} = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.32496$

$V_u = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s\text{jacket}} + V_{s\text{core}} = 881489.011$

where:

$V_{s\text{jacket}} = V_{s\text{j1}} + V_{s\text{j2}} = 802851.456$

$V_{s\text{j1}} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

Av = 157079.633

fy = 555.5556

s = 100.00

Vs,j1 is multiplied by Col,j1 = 1.00

s/d = 0.3125

Vs,j2 = 523598.776 is calculated for section flange jacket, with:

d = 600.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.16666667

Vs,core = Vs,c1 + Vs,c2 = 78637.555

Vs,c1 = 0.00 is calculated for section web core, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c1 is multiplied by Col,c1 = 0.00

s/d = 1.5625

Vs,c2 = 78637.555 is calculated for section flange core, with:

d = 440.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c2 is multiplied by Col,c2 = 1.00

s/d = 0.56818182

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 838832.606

bw = 400.00

-----  
End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 2  
-----

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjlcs

Constant Properties  
-----

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength, fc = fcm = 33.00

New material of Primary Member: Steel Strength, fs = fsm = 555.5556

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00

Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444

Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00

Max Height, Hmax = 750.00

Min Height, Hmin = 400.00

Max Width, Wmax = 750.00

Min Width, Wmin = 400.00

Jacket Thickness, tj = 100.00

Cover Thickness, c = 25.00

Element Length, L = 3000.00

Primary Member

Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d >= 1$ )  
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = 46459.419$   
Shear Force,  $V2 = 4191.702$   
Shear Force,  $V3 = -76.96362$   
Axial Force,  $F = -16698.158$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{c,com} = 2208.54$   
-Middle:  $As_{c,mid} = 2007.478$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,jacket} = 829.3805$   
-Compression:  $As_{c,com,jacket} = 1746.726$   
-Middle:  $As_{c,mid,jacket} = 1545.664$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,core} = 307.8761$   
-Compression:  $As_{c,com,core} = 461.8141$   
-Middle:  $As_{c,mid,core} = 461.8141$   
Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = \alpha \cdot u = 0.00265787$   
 $u = y + p = 0.00265787$

- Calculation of  $y$  -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00042778$  ((4.29), Biskinis Phd))  
 $M_y = 6.1989E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 300.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.4491E+014$   
factor = 0.30  
 $A_g = 440000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot \text{Area}_{jacket} + f_c'_{core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 27.68182$   
 $N = 16698.158$   
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:  
flange width,  $b = 750.00$   
web width,  $b_w = 400.00$   
flange thickness,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 4.6432325E-006$   
with  $f_y = 529.9948$   
 $d = 707.00$   
 $y = 0.19276172$   
 $A = 0.01015517$

B = 0.00446558  
 with pt = 0.00434791  
   pc = 0.00416509  
   pv = 0.00378591  
   N = 16698.158  
   b = 750.00  
   " = 0.06082037  
 y\_comp = 1.6223186E-005  
 with fc = 33.00  
   Ec = 26999.444  
   y = 0.19181213  
   A = 0.01002419  
   B = 0.00440616  
   with Es = 200000.00  
 CONFIRMATION: y = 0.19276172 < t/d

-----  
 Calculation of ratio lb/d

-----  
 Adequate Lap Length: lb/d >= 1

-----  
 - Calculation of p -

-----  
 From table 10-8: p = 0.00223009

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/d >= 1  
 shear control ratio  $V_y E / V_{ColOE} = 1.11182$

d = d\_external = 707.00

s = s\_external = 0.00

- t = s1 + s2 + 2\*tf/bw\*(ffe/fs) = 0.00434791

jacket: s1 = Av1\*Lstir1/(s1\*Ag) = 0.00367709

Av1 = 78.53982, is the area of every stirrup parallel to loading (shear) direction

Lstir1 = 2060.00, is the total Length of all stirrups parallel to loading (shear) direction

s1 = 100.00

core: s2 = Av2\*Lstir2/(s2\*Ag) = 0.00067082

Av2 = 50.26548, is the area of every stirrup parallel to loading (shear) direction

Lstir2 = 1468.00, is the total Length of all stirrups parallel to loading (shear) direction

s2 = 250.00

The term 2\*tf/bw\*(ffe/fs) is implemented to account for FRP contribution

where f = 2\*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation fs of jacket is used.

NUD = 16698.158

Ag = 440000.00

f<sub>cE</sub> = (f<sub>c\_jacket</sub>\*Area<sub>jacket</sub>+f<sub>c\_core</sub>\*Area<sub>core</sub>)/section\_area = 27.68182

f<sub>yE</sub> = (f<sub>y\_ext\_Long\_Reinf</sub>\*Area<sub>ext\_Long\_Reinf</sub>+f<sub>y\_int\_Long\_Reinf</sub>\*Area<sub>int\_Long\_Reinf</sub>)/Area<sub>Tot\_Long\_Rein</sub> = 529.9948

f<sub>ytE</sub> = (f<sub>y\_ext\_Trans\_Reinf</sub>\* s1+f<sub>y\_int\_Trans\_Reinf</sub>\* s2)/( s1+ s2) = 538.4128

pl = Area<sub>Tot\_Long\_Rein</sub>/(b\*d) = 0.01009575

b = 750.00

d = 707.00

f<sub>cE</sub> = 27.68182

-----  
 End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

## Calculation No. 9

column C1, Floor 1

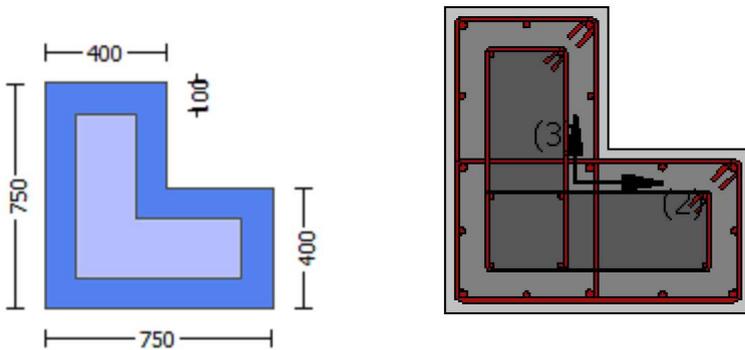
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjlcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.4444$

#####

Max Height, Hmax = 750.00  
Min Height, Hmin = 400.00  
Max Width, Wmax = 750.00  
Min Width, Wmin = 400.00  
Jacket Thickness, tj = 100.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{o,u,min} = l_b/l_d \geq 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

EDGE -A-  
Bending Moment, Ma = -1.5711E+007  
Shear Force, Va = -5216.58  
EDGE -B-  
Bending Moment, Mb = 57815.565  
Shear Force, Vb = 5216.58  
BOTH EDGES  
Axial Force, F = -16801.96  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: Aslt = 0.00  
-Compression: Aslc = 5353.274  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten = 1137.257  
-Compression: Asl,com = 2208.54  
-Middle: Asl,mid = 2007.478  
Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR =  $\phi V_n = 876312.539$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 876312.539$   
 $V_{CoI} = 876312.539$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.01485931  
-----

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} + \phi \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).  
-----

= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 21.31818$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $M_u = 1.5711E+007$   
 $V_u = 5216.58$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16801.96$   
 $A_g = 300000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 793340.11$   
where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$   
 $V_{s,j1} = 251327.412$  is calculated for section web jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,j2} = 471238.898$  is calculated for section flange jacket, with:

$d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 0.00$   
 $s/d = 1.5625$   
 $V_{s,c2} = 70773.799$  is calculated for section flange core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 736127.561$   
 $bw = 400.00$

-----  
 displacement ductility demand is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END A -  
 for rotation axis 3 and integ. section (a)

-----  
 From analysis, chord rotation  $\theta = 6.3818854E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00429487$  ((4.29), Biskinis Phd)  
 $M_y = 6.1992E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3011.833  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$   
 $factor = 0.30$   
 $A_g = 440000.00$   
 Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16801.96$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

-----  
 Calculation of Yielding Moment  $M_y$

-----  
 Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

-----  
 Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$   
 web width,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

-----  
 $y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 4.6432800E-006$   
 with  $f_y = 529.9948$   
 $d = 707.00$   
 $y = 0.19276996$   
 $A = 0.01015554$   
 $B = 0.00446595$   
 with  $pt = 0.00214476$   
 $pc = 0.00416509$   
 $pv = 0.00378591$   
 $N = 16801.96$   
 $b = 750.00$   
 $\phi = 0.06082037$

y\_comp = 1.6222985E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.1918145  
A = 0.01002374  
B = 0.00440616  
with Es = 200000.00  
CONFIRMATION: y = 0.19276996 < t/d

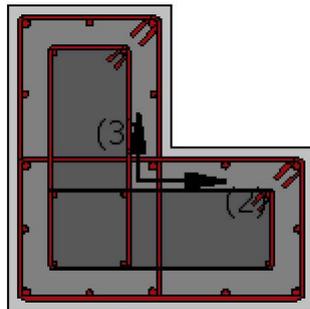
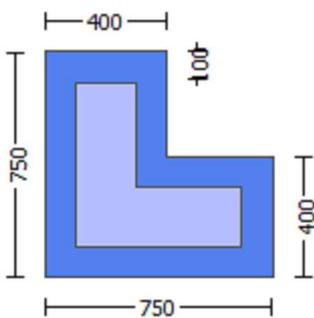
Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1  
At local axis: 2  
Integration Section: (a)

## Calculation No. 10

column C1, Floor 1  
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Chord rotation capacity ( u )  
Edge: Start  
Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At Shear local axis: 3  
(Bending local axis: 2)  
Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:

```

Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
#####
Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22693
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lo,min>= 1)
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force, Va = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
-----
-----

Calculation of Shear Capacity ratio , Ve/Vr = 1.11182
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1099E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6649E+009
Mu1+ = 1.0958E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
Mu1- = 1.6649E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6649E+009
Mu2+ = 1.0958E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination

```

Mu2- = 1.6649E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of Mu1+  
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 5.0126992E-005$$

$$Mu = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

-----  
$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

-----  
$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$
  
-----

$A_{sec} = 440000.00$   
 $s_1 = 100.00$   
 $s_2 = 250.00$   
 $fy_{we1} = 694.4444$   
 $fy_{we2} = 555.5556$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 788.2136$   
 $fy_1 = 656.8447$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_1\_nominal = 0.08$ ,  
 For calculation of  $esu_1\_nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * A_{sl, ten, jacket} + fs_{core} * A_{sl, ten, core}) / A_{sl, ten} = 656.8447$   
 with  $Es_1 = (Es_{jacket} * A_{sl, ten, jacket} + Es_{core} * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 798.4827$   
 $fy_2 = 665.4022$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 1.00$   
 $su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 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.  
 with  $fs_2 = (fs_{jacket} * A_{sl, com, jacket} + fs_{core} * A_{sl, com, core}) / A_{sl, com} = 665.4022$   
 with  $Es_2 = (Es_{jacket} * A_{sl, com, jacket} + Es_{core} * A_{sl, com, core}) / A_{sl, com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 794.9922$   
 $fy_v = 662.4935$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs_{jacket} * A_{sl, mid, jacket} + fs_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 662.4935$   
 with  $Es_v = (Es_{jacket} * A_{sl, mid, jacket} + Es_{mid} * A_{sl, mid, core}) / A_{sl, mid} = 200000.00$   
 $1 = A_{sl, ten} / (b * d) * (fs_1 / f_c) = 0.04269004$   
 $2 = A_{sl, com} / (b * d) * (fs_2 / f_c) = 0.08398367$   
 $v = A_{sl, mid} / (b * d) * (fsv / f_c) = 0.07600422$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04845844$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09533179$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture  
satisfies Eq. (4.3)

--->  
v < v<sub>s,y2</sub> - LHS eq.(4.5) is satisfied

$$\text{su (4.9)} = 0.09705994$$

$$\text{Mu} = \text{MRc (4.14)} = 1.0958\text{E}+009$$

$$u = \text{su (4.1)} = 5.0126992\text{E}-005$$

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565\text{E}-005$$

$$\text{Mu} = 1.6649\text{E}+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of A<sub>noConf</sub>, A<sub>conf,min</sub> and A<sub>conf,max</sub> are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A<sub>conf,max1</sub> = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

A<sub>conf,min1</sub> = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A<sub>conf,max1</sub> by a length equal to half the clear spacing between external hoops.

A<sub>noConf1</sub> = 158733.333 is the unconfined external core area which is equal to b<sub>i</sub><sup>2</sup>/6 as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of A<sub>noConf</sub>, A<sub>conf,min</sub> and A<sub>conf,max</sub> are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

A<sub>conf,max2</sub> = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

A<sub>conf,min2</sub> = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area A<sub>conf,max2</sub> by a length equal to half the clear spacing between internal hoops.

A<sub>noConf2</sub> = 106242.667 is the unconfined internal core area which is equal to b<sub>i</sub><sup>2</sup>/6 as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh\_x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

psh1 ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y \* Fywe = psh1 \* Fywe1 + ps2 \* Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 798.4827

fy1 = 665.4022

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 =  $0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

with Es1 =  $(E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 * esu2_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$

with Es2 =  $(E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv =  $0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 662.4935$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.15746938$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.08004382$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.14250792$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 40.48856

$cc$  (5A.5, TBDY) = 0.00426926

$c = \text{confinement factor} = 1.22693$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.19346746$

$2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.09834213$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs_{y2}$  - LHS eq.(4.5) is not satisfied

--->

$v < vs_{c}$  - RHS eq.(4.5) is satisfied

--->

$su$  (4.8) = 0.28813219

$Mu = MRc$  (4.15) = 1.6649E+009

$u = su$  (4.1) = 6.3581565E-005

Calculation of ratio  $lb/ld$

Adequate Lap Length:  $lb/ld \geq 1$

Calculation of  $Mu_{2+}$

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 5.0126992E-005$

$Mu = 1.0958E+009$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.01155629$

$we$  (5.4c) = 0.04056485

$ase$  ((5.4d), TBDY) =  $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase_2 (>= ase_1) = \text{Max}(((A_{conf,max2} - \text{AnoConf}_2)/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.92621$

$psh_1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$psh_2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 2.92621$

$psh_1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$psh_2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00426926$

$c =$  confinement factor = 1.22693

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 788.2136$

$fy_1 = 656.8447$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su_1 = 0.4 * esu_{1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,

For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fs_1 = fs_1/1.2$ , 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  $fs_1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 656.8447$

with  $Es_1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 798.4827$

$fy_2 = 665.4022$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 * esu_{2,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $es_{u2\_nominal}$  and  $y_2$ ,  $sh_2, ft_2, fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 665.4022$

with  $Es_2 = (Es_{jacket} \cdot Asl_{,com,jacket} + Es_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 1.00$

$suv = 0.4 \cdot es_{u\_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{u\_nominal} = 0.08$ ,

considering characteristic value  $fs_{yv} = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $es_{u\_nominal}$  and  $y_v$ ,  $sh_v, ft_v, fy_v$ , it is considered characteristic value  $fs_{yv} = fsv/1.2$ , 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  $fsv = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 662.4935$

with  $Es_v = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04269004$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.08398367$

$v = Asl_{,mid} / (b \cdot d) \cdot (fsv / fc) = 0.07600422$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 40.48856

$cc$  (5A.5, TBDY) = 0.00426926

$c$  = confinement factor = 1.22693

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04845844$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09533179$

$v = Asl_{,mid} / (b \cdot d) \cdot (fsv / fc) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.09705994

$Mu = MRc$  (4.14) = 1.0958E+009

$u = su$  (4.1) = 5.0126992E-005

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$

$Mu = 1.6649E+009$

-----  
with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174378$

$N = 16273.616$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.01155629$

$w_e$  (5.4c) = 0.04056485

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00426926$

$c$  = confinement factor = 1.22693

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 798.4827$

$fy1 = 665.4022$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/d = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered

characteristic value  $f_{sy1} = f_{s1}/1.2$ , 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  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 665.4022$

with  $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 788.2136$

$fy_2 = 656.8447$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{d,min} = 1.00$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered

characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 656.8447$

with  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 662.4935$

with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.15746938$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.08004382$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.14250792$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 40.48856$

$cc (5A.5, TBDY) = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.19346746$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.09834213$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

---->

$su (4.8) = 0.28813219$

$Mu = MRc (4.15) = 1.6649E+009$

$u = su (4.1) = 6.3581565E-005$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 998292.205$

$k_{nl} = 1$  (zero step-static loading)  
-----

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31807$

$V_u = 0.00051441$

$d = 0.8 * h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $\text{Col},j2 = 1.00$

$s/d = 0.3125$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $\text{Col},c2 = 0.00$

$s/d = 1.5625$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$b_w = 400.00$   
-----

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 998292.205$

$k_{nl} = 1$  (zero step-static loading)  
-----

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31753$

$V_u = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{sjacket} + V_{s,core} = 881489.011$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$

$V_{sj1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{sj1}$  is multiplied by  $Col,j1 = 1.00$

$s/d = 0.16666667$

$V_{sj2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{sj2}$  is multiplied by  $Col,j2 = 1.00$

$s/d = 0.3125$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$

$s/d = 1.5625$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$bw = 400.00$

-----

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At local axis: 3

-----

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcjlc

Constant Properties

-----

Knowledge Factor,  $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.  
Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $fc = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
 Concrete Elasticity,  $E_c = 21019.039$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Jacket  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$   
 Existing Column  
 Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$   
 #####  
 Max Height,  $H_{max} = 750.00$   
 Min Height,  $H_{min} = 400.00$   
 Max Width,  $W_{max} = 750.00$   
 Min Width,  $W_{min} = 400.00$   
 Jacket Thickness,  $t_j = 100.00$   
 Cover Thickness,  $c = 25.00$   
 Mean Confinement Factor overall section = 1.22693  
 Element Length,  $L = 3000.00$   
 Primary Member  
 Ribbed Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{ou, min} >= 1$ )  
 No FRP Wrapping

-----  
 Stepwise Properties  
 -----

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -0.00051441$   
 EDGE -B-  
 Shear Force,  $V_b = 0.00051441$   
 BOTH EDGES  
 Axial Force,  $F = -16273.616$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl} = 0.00$   
 -Compression:  $A_{slc} = 5353.274$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl, ten} = 1137.257$   
 -Compression:  $A_{sl, com} = 2208.54$   
 -Middle:  $A_{sl, mid} = 2007.478$

-----  
 Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.11182$   
 Member Controlled by Shear ( $V_e/V_r > 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
 with  
 $M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.6649E+009$   
 $M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $M_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.6649E+009$   
 $M_{u2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
 which is defined for the the static loading combination  
 $M_{u2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
 direction which is defined for the the static loading combination

-----  
 Calculation of  $M_{u1+}$   
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 5.0126992E-005$$

$$\mu = 1.0958E+009$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01155629$$

$$\phi_{cc} \text{ (5.4c)} = 0.04056485$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase1} * A_{\text{ext}} + \text{ase2} * A_{\text{int}}) / A_{\text{sec}} = 0.45746528$$

$$\text{ase1} = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}}) / A_{\text{conf,max1}}) * (A_{\text{conf,min1}} / A_{\text{conf,max1}}), 0) = 0.45746528$$

The definitions of  $A_{\text{noConf}}$ ,  $A_{\text{conf,min}}$  and  $A_{\text{conf,max}}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max1}} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{\text{conf,min1}} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{\text{conf,max1}}$  by a length equal to half the clear spacing between external hoops.

$A_{\text{noConf1}} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$\text{ase2} (> = \text{ase1}) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}}) / A_{\text{conf,max2}}) * (A_{\text{conf,min2}} / A_{\text{conf,max2}}), 0) = 0.45746528$$

The definitions of  $A_{\text{noConf}}$ ,  $A_{\text{conf,min}}$  and  $A_{\text{conf,max}}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max2}} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{\text{conf,min2}} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{\text{conf,max2}}$  by a length equal to half the clear spacing between internal hoops.

$A_{\text{noConf2}} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$\text{psh}_{\text{min}} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 2.92621$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.92621$$

$$\text{psh}_1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00367709$$

$$L_{\text{stir1}} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{\text{stir1}} \text{ (stirrups area)} = 78.53982$$

$$\text{psh}_2 \text{ (5.4d)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00067082$$

$$L_{\text{stir2}} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{\text{stir2}} \text{ (stirrups area)} = 50.26548$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.92621$$

$$\text{psh}_1 \text{ ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00367709$$

$$L_{\text{stir1}} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{\text{stir1}} \text{ (stirrups area)} = 78.53982$$

$$\text{psh}_2 \text{ ((5.4d), TBDY)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00067082$$

$$L_{\text{stir2}} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{\text{stir2}} \text{ (stirrups area)} = 50.26548$$

$$A_{\text{sec}} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs,jacket * Asl,ten,jacket + fs,core * Asl,ten,core) / Asl,ten = 656.8447$

with  $Es1 = (Es,jacket * Asl,ten,jacket + Es,core * Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 798.4827$

$fy2 = 665.4022$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/lb,min = 1.00$

$su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs,jacket * Asl,com,jacket + fs,core * Asl,com,core) / Asl,com = 665.4022$

with  $Es2 = (Es,jacket * Asl,com,jacket + Es,core * Asl,com,core) / Asl,com = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 794.9922$

$fyv = 662.4935$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou,min = lb/ld = 1.00$

$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs,jacket * Asl,mid,jacket + fs,mid * Asl,mid,core) / Asl,mid = 662.4935$

with  $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.04269004$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.08398367$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.07600422$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 40.48856$

$cc (5A.5, TBDY) = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.04845844$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.09533179$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.09705994$$

$$\mu_u = MR_c(4.14) = 1.0958E+009$$

$$u = s_u(4.1) = 5.0126992E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $\mu_{u1}$ -

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu_u = 1.6649E+009$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e(5.4c) = 0.04056485$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1}(\text{Length of stirrups along } Y) = 2060.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2}(\text{Length of stirrups along } Y) = 1468.00$$

$$A_{stir2}(\text{stirrups area}) = 50.26548$$

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 2.92621  
psh<sub>1</sub> ((5.4d), TBDY) = Lstir<sub>1</sub>\*Astir<sub>1</sub>/(Asec\*s<sub>1</sub>) = 0.00367709  
Lstir<sub>1</sub> (Length of stirrups along X) = 2060.00  
Astir<sub>1</sub> (stirrups area) = 78.53982  
psh<sub>2</sub> ((5.4d), TBDY) = Lstir<sub>2</sub>\*Astir<sub>2</sub>/(Asec\*s<sub>2</sub>) = 0.00067082  
Lstir<sub>2</sub> (Length of stirrups along X) = 1468.00  
Astir<sub>2</sub> (stirrups area) = 50.26548

Asec = 440000.00  
s<sub>1</sub> = 100.00  
s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.4444  
fywe<sub>2</sub> = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y<sub>1</sub> = 0.0025  
sh<sub>1</sub> = 0.008  
ft<sub>1</sub> = 798.4827  
fy<sub>1</sub> = 665.4022  
su<sub>1</sub> = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>d</sub> = 1.00

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,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

with Es<sub>1</sub> = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y<sub>2</sub> = 0.0025  
sh<sub>2</sub> = 0.008  
ft<sub>2</sub> = 788.2136  
fy<sub>2</sub> = 656.8447  
su<sub>2</sub> = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>b,min</sub> = 1.00

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>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>2</sub> = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

with Es<sub>2</sub> = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

y<sub>v</sub> = 0.0025  
sh<sub>v</sub> = 0.008  
ft<sub>v</sub> = 794.9922  
fy<sub>v</sub> = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/l<sub>d</sub> = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsyv = fsv/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 fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Es<sub>v</sub> = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs<sub>1</sub>/fc) = 0.15746938

$$2 = A_{sl,com}/(b*d)^*(f_{s2}/f_c) = 0.08004382$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{sl,ten}/(b*d)^*(f_{s1}/f_c) = 0.19346746$$

$$2 = A_{sl,com}/(b*d)^*(f_{s2}/f_c) = 0.09834213$$

$$v = A_{sl,mid}/(b*d)^*(f_{sv}/f_c) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.28813219$$

$$\mu_u = M_{Rc} (4.15) = 1.6649E+009$$

$$u = s_u (4.1) = 6.3581565E-005$$

-----  
Calculation of ratio  $l_b/d$

-----  
Adequate Lap Length:  $l_b/d \geq 1$

-----  
Calculation of  $\mu_{u2+}$

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 5.0126992E-005$$

$$\mu_u = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$

with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 798.4827$

$fy2 = 665.4022$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y2, sh2, ft2, fy2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 665.4022$

with  $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$

$shv = 0.008$   
 $ftv = 794.9922$   
 $fyv = 662.4935$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv,ftv,fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1,ft1,fy1$ , are also multiplied by  $Min(1,1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935$   
 with  $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04269004$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.08398367$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.07600422$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.04845844$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.09533179$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---

$v < vs,y2$  - LHS eq.(4.5) is satisfied

---

$su (4.9) = 0.09705994$   
 $Mu = MRc (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $lb/ld$

-----  
 Adequate Lap Length:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu2$ -  
 -----  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$   
 $Mu = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max( cu, cc) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01155629$   
 $we (5.4c) = 0.04056485$   
 $ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528$   
 $ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1),0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 798.4827$

$fy1 = 665.4022$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$  and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  $Shear\_factor = 1.00$

$lo/lo_{min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 665.4022$

with  $Es1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$$ft2 = 788.2136$$

$$fy2 = 656.8447$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 656.8447$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 794.9922$$

$$fyv = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 662.4935$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.15746938$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.08004382$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.19346746$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09834213$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$  - LHS eq.(4.5) is not satisfied

---->

$v < vs,c$  - RHS eq.(4.5) is satisfied

---->

$$su (4.8) = 0.28813219$$

$$Mu = MRc (4.15) = 1.6649E+009$$

$$u = su (4.1) = 6.3581565E-005$$

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length:  $lb/ld \geq 1$

-----  
Calculation of Shear Strength  $Vr = \text{Min}(Vr1, Vr2) = 998292.205$

-----  
Calculation of Shear Strength at edge 1,  $Vr1 = 998292.205$

$Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO$

VCol0 = 998292.205  
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
M/Vd = 4.00  
Mu = 13.32441  
Vu = 0.00051441  
d = 0.8 \* h = 600.00  
Nu = 16273.616  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$   
where:  
 $V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 279252.68$  is calculated for section web jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.5556  
s = 100.00  
 $V_{s,j1}$  is multiplied by Col,j1 = 1.00  
s/d = 0.3125  
 $V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:  
d = 600.00  
Av = 157079.633  
fy = 555.5556  
s = 100.00  
 $V_{s,j2}$  is multiplied by Col,j2 = 1.00  
s/d = 0.16666667  
 $V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.4444  
s = 250.00  
 $V_{s,c1}$  is multiplied by Col,c1 = 0.00  
s/d = 1.5625  
 $V_{s,c2} = 78637.555$  is calculated for section flange core, with:  
d = 440.00  
Av = 100530.965  
fy = 444.4444  
s = 250.00  
 $V_{s,c2}$  is multiplied by Col,c2 = 1.00  
s/d = 0.56818182  
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 998292.205  
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = \text{knl} \cdot V_{\text{Col}0}$   
VCol0 = 998292.205  
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
M/Vd = 4.00  
Mu = 13.32496  
Vu = 0.00051441  
d = 0.8 \* h = 600.00

Nu = 16273.616  
Ag = 300000.00  
From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$   
where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 279252.68$  is calculated for section web jacket, with:  
d = 320.00  
Av = 157079.633  
fy = 555.5556  
s = 100.00  
 $V_{s,j1}$  is multiplied by Col,j1 = 1.00  
s/d = 0.3125  
 $V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:  
d = 600.00  
Av = 157079.633  
fy = 555.5556  
s = 100.00  
 $V_{s,j2}$  is multiplied by Col,j2 = 1.00  
s/d = 0.16666667  
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
d = 160.00  
Av = 100530.965  
fy = 444.4444  
s = 250.00  
 $V_{s,c1}$  is multiplied by Col,c1 = 0.00  
s/d = 1.5625  
 $V_{s,c2} = 78637.555$  is calculated for section flange core, with:  
d = 440.00  
Av = 100530.965  
fy = 444.4444  
s = 250.00  
 $V_{s,c2}$  is multiplied by Col,c2 = 1.00  
s/d = 0.56818182  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
bw = 400.00

-----  
-----  
End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At local axis: 2

-----  
-----  
Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2  
Integration Section: (a)  
Section Type: rcjlcs

Constant Properties

-----  
Knowledge Factor, = 1.00  
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
Max Height,  $H_{max} = 750.00$

Min Height, Hmin = 400.00  
Max Width, Wmax = 750.00  
Min Width, Wmin = 400.00  
Jacket Thickness, tj = 100.00  
Cover Thickness, c = 25.00  
Element Length, L = 3000.00  
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/d \geq 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

Bending Moment, M = -196550.732  
Shear Force, V2 = -5216.58  
Shear Force, V3 = 95.78147  
Axial Force, F = -16801.96  
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension: Aslt = 0.00  
-Compression: Aslc = 5353.274  
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten = 1137.257  
-Compression: Asl,com = 2208.54  
-Middle: Asl,mid = 2007.478  
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten,jacket = 829.3805  
-Compression: Asl,com,jacket = 1746.726  
-Middle: Asl,mid,jacket = 1545.664  
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension: Asl,ten,core = 307.8761  
-Compression: Asl,com,core = 461.8141  
-Middle: Asl,mid,core = 461.8141  
Mean Diameter of Tension Reinforcement, DbL = 16.80

-----  
Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = \rho u = 0.03651772$   
 $u = \rho y + \rho p = 0.03651772$

-----  
- Calculation of  $\rho y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00292626$  ((4.29), Biskinis Phd))  
 $M_y = 6.1992E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2052.075  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$   
factor = 0.30  
 $A_g = 440000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16801.96$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

-----  
Calculation of Yielding Moment  $M_y$   
-----

Calculation of  $\rho y$  and  $M_y$  according to Annex 7 -  
-----

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:  
flange width, b = 750.00  
web width, bw = 400.00  
flange thickness, t = 400.00

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 4.6432800\text{E}-006$   
 with  $f_y = 529.9948$   
 $d = 707.00$   
 $y = 0.19276996$   
 $A = 0.01015554$   
 $B = 0.00446595$   
 with  $p_t = 0.00434791$   
 $p_c = 0.00416509$   
 $p_v = 0.00378591$   
 $N = 16801.96$   
 $b = 750.00$   
 $" = 0.06082037$

$y_{\text{comp}} = 1.6222985\text{E}-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.1918145$   
 $A = 0.01002374$   
 $B = 0.00440616$   
 with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03359146$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/d \geq 1$

shear control ratio  $V_y E / V_{CoI} E = 1.11182$

$d = d_{\text{external}} = 707.00$

$s = s_{\text{external}} = 0.00$

-  $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00434791$

jacket:  $s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$

$A_{v2} = 50.26548$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

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.

$N_{UD} = 16801.96$

$A_g = 440000.00$

$f_{cE} = (f_{c\_jacket} \cdot \text{Area}_{\text{jacket}} + f_{c\_core} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 27.68182$

$f_{yIE} = (f_{y\_ext\_Long\_Reinf} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 529.9948$

$f_{yIE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$

$p_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01009575$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (a)

## Calculation No. 11

column C1, Floor 1

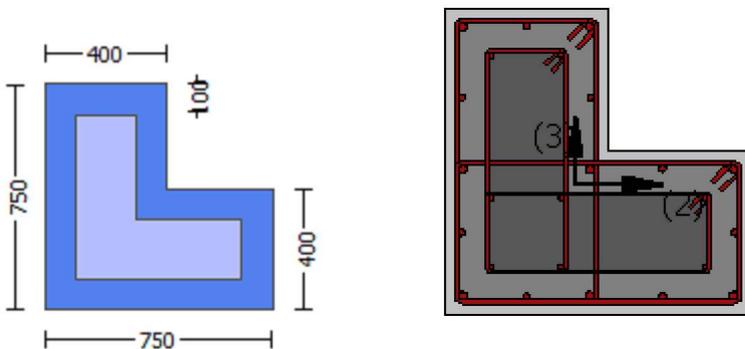
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjics

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.4444$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -196550.732$

Shear Force,  $V_a = 95.78147$

EDGE -B-

Bending Moment,  $M_b = -89327.543$

Shear Force,  $V_b = -95.78147$

BOTH EDGES

Axial Force,  $F = -16801.96$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 1137.257$

-Compression:  $A_{sc,com} = 2208.54$

-Middle:  $A_{st,mid} = 2007.478$

Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 900080.632$

$V_n$  (10.3), ASCE 41-17) =  $k_n \cdot V_{CoI0} = 900080.632$

$V_{CoI} = 900080.632$

$k_n = 1.00$

displacement\_ductility\_demand = 0.00853992

-----  
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:  $f'_c = (f'_c_{jacket} \cdot Area_{jacket} + f'_c_{core} \cdot Area_{core}) / Area_{section} = 21.31818$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 3.42012$

$M_u = 196550.732$

$V_u = 95.78147$

$d = 0.8 \cdot h = 600.00$

$N_u = 16801.96$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{sjacket} + V_{s,core} = 793340.11$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 722566.31$

$V_{sj1} = 471238.898$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 251327.412$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$   
 $V_{s,c1} = 70773.799$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$   
 $s/d = 0.56818182$   
 $V_{s,c2} = 0.00$  is calculated for section flange core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 736127.561$   
 $bw = 400.00$

-----  
 displacement ductility demand is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END A -  
 for rotation axis 2 and integ. section (a)

-----  
 From analysis, chord rotation  $\theta = 2.4990000E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00292626$  ((4.29), Biskinis Phd))  
 $M_y = 6.1992E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2052.075  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$   
 $factor = 0.30$   
 $A_g = 440000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16801.96$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

-----  
 Calculation of Yielding Moment  $M_y$

-----  
 Calculation of  $\phi / y$  and  $M_y$  according to Annex 7 -

-----  
 Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$   
 web width,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

-----  
 $y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 4.6432800E-006$   
 with  $f_y = 529.9948$   
 $d = 707.00$   
 $y = 0.19276996$   
 $A = 0.01015554$   
 $B = 0.00446595$   
 with  $pt = 0.00214476$   
 $pc = 0.00416509$

pv = 0.00378591  
N = 16801.96  
b = 750.00  
" = 0.06082037  
y\_comp = 1.6222985E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.1918145  
A = 0.01002374  
B = 0.00440616  
with Es = 200000.00  
CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (a)

## Calculation No. 12

column C1, Floor 1

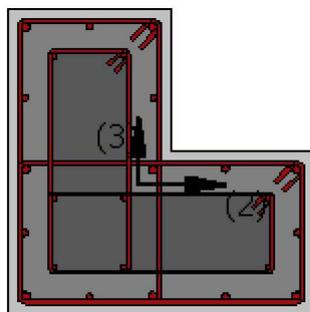
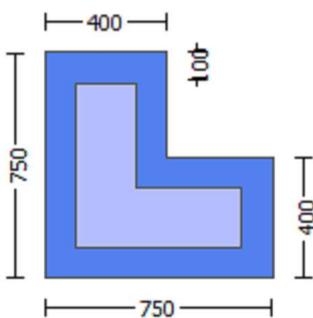
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjlc

Constant Properties

-----  
Knowledge Factor,  $\phi = 1.00$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength,  $f_s = 1.25 * f_{sm} = 694.4444$   
Existing Column  
Existing material: Steel Strength,  $f_s = 1.25 * f_{sm} = 555.5556$   
#####  
Max Height,  $H_{max} = 750.00$   
Min Height,  $H_{min} = 400.00$   
Max Width,  $W_{max} = 750.00$   
Min Width,  $W_{min} = 400.00$   
Jacket Thickness,  $t_j = 100.00$   
Cover Thickness,  $c = 25.00$   
Mean Confinement Factor overall section = 1.22693  
Element Length,  $L = 3000.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou, min} > 1$ )  
No FRP Wrapping  
-----

Stepwise Properties

-----  
At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -0.00051441$   
EDGE -B-  
Shear Force,  $V_b = 0.00051441$   
BOTH EDGES  
Axial Force,  $F = -16273.616$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st, ten} = 1137.257$   
-Compression:  $A_{sl, com} = 2208.54$   
-Middle:  $A_{sl, mid} = 2007.478$   
-----  
-----

-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$   
Member Controlled by Shear ( $V_e/V_r > 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6649E+009$   
 $M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $M_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
-----

direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6649E+009$$

$M_{u2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 5.0126992E-005$$

$$M_u = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01155629$$

$$\omega_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

psh2 ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 =  $0.4 * esu1\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(f_s,jacket * A_{sl,ten,jacket} + f_s,core * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$

with Es1 =  $(E_s,jacket * A_{sl,ten,jacket} + E_s,core * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 * esu2\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(f_s,jacket * A_{sl,com,jacket} + f_s,core * A_{sl,com,core}) / A_{sl,com} = 665.4022$

with Es2 =  $(E_s,jacket * A_{sl,com,jacket} + E_s,core * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv =  $0.4 * esuv\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $Min(1, 1.25 * (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv =  $(f_s,jacket * A_{sl,mid,jacket} + f_s,mid * A_{sl,mid,core}) / A_{sl,mid} = 662.4935$

with Esv =  $(E_s,jacket * A_{sl,mid,jacket} + E_s,mid * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

1 =  $A_{sl,ten} / (b * d) * (fs1 / fc) = 0.04269004$

2 =  $A_{sl,com} / (b * d) * (fs2 / fc) = 0.08398367$

v =  $A_{sl,mid} / (b * d) * (fsv / fc) = 0.07600422$

and confined core properties:

b = 690.00

d = 677.00

$d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04845844$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09533179$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08627414$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->

$su (4.9) = 0.09705994$   
 $Mu = MRc (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $l_b/d$

-----  
 Adequate Lap Length:  $l_b/d \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu1$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$   
 $Mu = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$   
 $f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01155629$

$we (5.4c) = 0.04056485$   
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.45746528$   
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * Fywe = \text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 =  $0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 665.4022$

with Es1 =  $(Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 656.8447$

with Es2 =  $(Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_0/l_{ou,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{suv,nominal} = 0.08$ ,

considering characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{suv,nominal}$  and  $\gamma_v$ ,  $sh_v, ft_v, fy_v$ , it is considered

characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.

$$\gamma_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 662.4935$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.15746938$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.08004382$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.19346746$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.09834213$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

---->

$$s_u (4.8) = 0.28813219$$

$$\mu_u = M_{Rc} (4.15) = 1.6649E+009$$

$$u = s_u (4.1) = 6.3581565E-005$$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 5.0126992E-005$$

$$\mu_u = 1.0958E+009$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
ase2 ( $\geq$  ase1) =  $\text{Max}((A_{\text{conf,max2}} - A_{\text{noConf2}})/A_{\text{conf,max2}} * (A_{\text{conf,min2}}/A_{\text{conf,max2}}), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
psh,min\*Fywe =  $\text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

psh\_x\*Fywe = psh1\*Fywe1 + ps2\*Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00367709$

Lstir1 (Length of stirrups along Y) = 2060.00

Astir1 (stirrups area) = 78.53982

psh2 (5.4d) =  $L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00067082$

Lstir2 (Length of stirrups along Y) = 1468.00

Astir2 (stirrups area) = 50.26548

psh\_y\*Fywe = psh1\*Fywe1 + ps2\*Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00367709$

Lstir1 (Length of stirrups along X) = 2060.00

Astir1 (stirrups area) = 78.53982

psh2 ((5.4d), TBDY) =  $L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00067082$

Lstir2 (Length of stirrups along X) = 1468.00

Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 =  $0.4 * e_{s1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 656.8447$

with Es1 =  $(E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04845844

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09533179

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.08627414

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is satisfied

--->

su (4.9) = 0.09705994

Mu = MRc (4.14) = 1.0958E+009

u = su (4.1) = 5.0126992E-005

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length: lb/ld >= 1

-----  
Calculation of Mu2-

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 6.3581565E-005

Mu = 1.6649E+009

-----  
with full section properties:

b = 400.00

d = 707.00

d' = 43.00

$$v = 0.00174378$$

$$N = 16273.616$$

$$fc = 33.00$$

$$co (5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01155629$$

$$we (5.4c) = 0.04056485$$

$$ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1) / Aconf,max1) * (Aconf,min1 / Aconf,max1), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max1 by a length

equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2) / Aconf,max2) * (Aconf,min2 / Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area Aconf,max2 by a length

equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$psh,min * Fywe = \text{Min}(psh,x * Fywe, psh,y * Fywe) = 2.92621$$

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 (\text{Length of stirrups along } Y) = 2060.00$$

$$Astir1 (\text{stirrups area}) = 78.53982$$

$$psh2 (5.4d) = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 (\text{Length of stirrups along } Y) = 1468.00$$

$$Astir2 (\text{stirrups area}) = 50.26548$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 2.92621$$

$$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$$

$$Lstir1 (\text{Length of stirrups along } X) = 2060.00$$

$$Astir1 (\text{stirrups area}) = 78.53982$$

$$psh2 ((5.4d), TBDY) = Lstir2 * Astir2 / (Asec * s2) = 0.00067082$$

$$Lstir2 (\text{Length of stirrups along } X) = 1468.00$$

$$Astir2 (\text{stirrups area}) = 50.26548$$

$$Asec = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.4444$$

$$fywe2 = 555.5556$$

$$fce = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 798.4827$$

$$fy1 = 665.4022$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

$$s_u1 = 0.4 \cdot e_{s1\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s1\_nominal} = 0.08,$$

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.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 665.4022$$

$$\text{with } E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 788.2136$$

$$fy_2 = 656.8447$$

$$s_u2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

$$l_0/l_{0u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 \cdot e_{s2\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{s2\_nominal} = 0.08,$$

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.

$$y_2, sh_2, ft_2, fy_2, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 656.8447$$

$$\text{with } E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

$$l_0/l_{0u,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 \cdot e_{suv\_nominal} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } e_{suv\_nominal} = 0.08,$$

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.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 662.4935$$

$$\text{with } E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15746938$$

$$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08004382$$

$$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14250792$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.19346746$$

$$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09834213$$

$$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.17508576$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$s_u (4.8) = 0.28813219$$

$$\mu_u = M R_c (4.15) = 1.6649E+009$$

$$u = s_u (4.1) = 6.3581565E-005$$

-----  
Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{Co10}$  ((10.3), ASCE 41-17) =  $k_n l V_{Co10}$

$V_{Co10} = 998292.205$

$k_n l = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31807$

$V_u = 0.00051441$

$d = 0.8h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$

$s/d = 0.3125$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{Co10}$  ((10.3), ASCE 41-17) =  $k_n l V_{Co10}$

$V_{Co10} = 998292.205$

$k_n l = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.31753$

$V_u = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $\text{Col},j1 = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $\text{Col},j2 = 1.00$

$s/d = 0.3125$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $\text{Col},c1 = 1.00$

$s/d = 0.56818182$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $\text{Col},c2 = 0.00$

$s/d = 1.5625$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$b_w = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjlc

Constant Properties

Knowledge Factor,  $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

```

New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
#####
Max Height, Hmax = 750.00
Min Height, Hmin = 400.00
Max Width, Wmax = 750.00
Min Width, Wmin = 400.00
Jacket Thickness, tj = 100.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.22693
Element Length, L = 3000.00
Primary Member
Ribbed Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force, Va = -0.00051441
EDGE -B-
Shear Force, Vb = 0.00051441
BOTH EDGES
Axial Force, F = -16273.616
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 5353.274
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1137.257
-Compression: Asl,com = 2208.54
-Middle: Asl,mid = 2007.478
-----
-----

Calculation of Shear Capacity ratio , Ve/Vr = 1.11182
Member Controlled by Shear (Ve/Vr > 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 1.1099E+006
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6649E+009
Mu1+ = 1.0958E+009, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
Mu1- = 1.6649E+009, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.6649E+009
Mu2+ = 1.0958E+009, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
Mu2- = 1.6649E+009, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

```

-----  
Calculation of Mu1+  
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 5.0126992E-005$$

$$\text{Mu} = 1.0958E+009$$

-----

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase1} * A_{\text{ext}} + \text{ase2} * A_{\text{int}}) / A_{\text{sec}} = 0.45746528$$

$$\text{ase1} = \text{Max}(((A_{\text{conf,max1}} - A_{\text{noConf1}}) / A_{\text{conf,max1}}) * (A_{\text{conf,min1}} / A_{\text{conf,max1}}), 0) = 0.45746528$$

The definitions of  $A_{\text{noConf}}$ ,  $A_{\text{conf,min}}$  and  $A_{\text{conf,max}}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max1}} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{\text{conf,min1}} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{\text{conf,max1}}$  by a length

equal to half the clear spacing between external hoops.

$A_{\text{noConf1}} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$\text{ase2} (> = \text{ase1}) = \text{Max}(((A_{\text{conf,max2}} - A_{\text{noConf2}}) / A_{\text{conf,max2}}) * (A_{\text{conf,min2}} / A_{\text{conf,max2}}), 0) = 0.45746528$$

The definitions of  $A_{\text{noConf}}$ ,  $A_{\text{conf,min}}$  and  $A_{\text{conf,max}}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{\text{conf,max2}} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{\text{conf,min2}} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{\text{conf,max2}}$  by a length

equal to half the clear spacing between internal hoops.

$A_{\text{noConf2}} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$\text{psh,min} * F_{yve} = \text{Min}(\text{psh,x} * F_{yve}, \text{psh,y} * F_{yve}) = 2.92621$$

-----

$$\text{psh,x} * F_{yve} = \text{psh1} * F_{yve1} + \text{ps2} * F_{yve2} = 2.92621$$

$$\text{psh1 ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00367709$$

$$L_{\text{stir1}} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{\text{stir1}} \text{ (stirrups area)} = 78.53982$$

$$\text{psh2 (5.4d)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00067082$$

$$L_{\text{stir2}} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{\text{stir2}} \text{ (stirrups area)} = 50.26548$$

-----

$$\text{psh,y} * F_{yve} = \text{psh1} * F_{yve1} + \text{ps2} * F_{yve2} = 2.92621$$

$$\text{psh1 ((5.4d), TBDY)} = L_{\text{stir1}} * A_{\text{stir1}} / (A_{\text{sec}} * s_1) = 0.00367709$$

$$L_{\text{stir1}} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{\text{stir1}} \text{ (stirrups area)} = 78.53982$$

$$\text{psh2 ((5.4d), TBDY)} = L_{\text{stir2}} * A_{\text{stir2}} / (A_{\text{sec}} * s_2) = 0.00067082$$

$$L_{\text{stir2}} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{\text{stir2}} \text{ (stirrups area)} = 50.26548$$

-----

$$A_{\text{sec}} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$$c = \text{confinement factor} = 1.22693$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 788.2136$$

$$fy_1 = 656.8447$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$$

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.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 656.8447$$

$$\text{with } Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 798.4827$$

$$fy_2 = 665.4022$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$$

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.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 665.4022$$

$$\text{with } Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$$

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.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 662.4935$$

$$\text{with } Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.04269004$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.08398367$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 40.48856$$

$$cc \text{ (5A.5, TBDY)} = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.04845844$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.09533179$$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture  
 satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.09705994$$

$$\mu = MR_c(4.14) = 1.0958E+009$$

$$u = s_u(4.1) = 5.0126992E-005$$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$\alpha(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} \cdot \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e(5.4c) = 0.04056485$$

$$a_{se}(5.4d), TBDY) = (a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 2.92621$$

$$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$$

$$p_{sh1}(5.4d), TBDY) = L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along } Y) = 2060.00$$

Astir1 (stirrups area) = 78.53982  
psh2 (5.4d) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
psh\_y \* Fywe = psh1 \* Fywe1 + ps2 \* Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 798.4827

fy1 = 665.4022

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 =  $0.4 \cdot esu1\_nominal$  ((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  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(f_{s,jacket} \cdot A_{sl,ten,jacket} + f_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

with Es1 =  $(E_{s,jacket} \cdot A_{sl,ten,jacket} + E_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(f_{s,jacket} \cdot A_{sl,com,jacket} + f_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 656.8447$

with Es2 =  $(E_{s,jacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv =  $0.4 \cdot esuv\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv, ftv, fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_s \cdot \text{jacket} \cdot A_{s, \text{mid, jacket}} + f_s \cdot \text{mid} \cdot A_{s, \text{mid, core}}) / A_{s, \text{mid}} = 662.4935$

with  $E_{sv} = (E_s \cdot \text{jacket} \cdot A_{s, \text{mid, jacket}} + E_s \cdot \text{mid} \cdot A_{s, \text{mid, core}}) / A_{s, \text{mid}} = 200000.00$

$1 = A_{s, \text{ten}} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15746938$

$2 = A_{s, \text{com}} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08004382$

$v = A_{s, \text{mid}} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14250792$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, \text{TBDY}) = 40.48856$

$cc (5A.5, \text{TBDY}) = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$1 = A_{s, \text{ten}} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.19346746$

$2 = A_{s, \text{com}} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09834213$

$v = A_{s, \text{mid}} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s, y2}$  - LHS eq.(4.5) is not satisfied

--->

$v < v_{s, c}$  - RHS eq.(4.5) is satisfied

--->

$su (4.8) = 0.28813219$

$Mu = MRc (4.15) = 1.6649E+009$

$u = su (4.1) = 6.3581565E-005$

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$

-----  
Calculation of  $Mu_{2+}$

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 5.0126992E-005$

$Mu = 1.0958E+009$

-----  
with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$f_c = 33.00$

$co (5A.5, \text{TBDY}) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.01155629$

$w_e (5.4c) = 0.04056485$

$ase ((5.4d), \text{TBDY}) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase1 = \text{Max}(((A_{conf, \text{max}1} - A_{noConf1}) / A_{conf, \text{max}1}) \cdot (A_{conf, \text{min}1} / A_{conf, \text{max}1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf, \text{min}}$  and  $A_{conf, \text{max}}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf, \text{max}1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf, \text{min}1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf, \text{max}1}$  by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $bi^2/6$  as defined at (A.2).

$$ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noconf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noconf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$$A_{noconf2} = 106242.667 \text{ is the unconfined internal core area which is equal to } b_i^2/6 \text{ as defined at (A.2).}$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou,min} = l_b / l_d = 1.00$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$$

$$\text{with } Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 798.4827$$

$$fy2 = 665.4022$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou,min} = l_b / l_{b,min} = 1.00$$

$$su2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2 / 1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 665.4022$

with  $Es_2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou, min = lb/d = 1.00$

$suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

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  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} \cdot A_{sl,mid,jacket} + fs_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 662.4935$

with  $Esv = (Es_{jacket} \cdot A_{sl,mid,jacket} + Es_{mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04269004$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.08398367$

$v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.07600422$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 40.48856

$cc$  (5A.5, TBDY) = 0.00426926

$c$  = confinement factor = 1.22693

$1 = A_{sl,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04845844$

$2 = A_{sl,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09533179$

$v = A_{sl,mid} / (b \cdot d) \cdot (fsv / fc) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.09705994

$Mu = MRc$  (4.14) = 1.0958E+009

$u = su$  (4.1) = 5.0126992E-005

-----  
Calculation of ratio  $lb/d$

-----  
Adequate Lap Length:  $lb/d \geq 1$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$

$Mu = 1.6649E+009$

-----  
with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174378$

$N = 16273.616$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.01155629$

$w_e$  (5.4c) = 0.04056485

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$

$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00426926$

$c$  = confinement factor = 1.22693

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 798.4827$

$fy_1 = 665.4022$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o / l_{ou,min} = l_b / l_d = 1.00$

$su_1 = 0.4 * esu_1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu_1_{nominal} = 0.08$ ,

For calculation of  $esu_1_{nominal}$  and  $y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , it is considered

characteristic value  $fsy_1 = fs_1 / 1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 665.4022$   
 with  $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 788.2136$   
 $fy_2 = 656.8447$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$   
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $f_{sy2} = f_{s2}/1.2$ , 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  $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 656.8447$   
 with  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 794.9922$   
 $fy_v = 662.4935$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_0/l_{ou,min} = l_b/l_d = 1.00$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $f_{syv} = f_{sv}/1.2$ , 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  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 662.4935$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.15746938$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08004382$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.14250792$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.19346746$   
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09834213$   
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.17508576$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is satisfied  
 --->  
 $su (4.8) = 0.28813219$   
 $\mu = MR_c (4.15) = 1.6649E+009$   
 $u = su (4.1) = 6.3581565E-005$

-----  
 Calculation of ratio  $l_b/l_d$   
 -----

Adequate Lap Length:  $l_b/l_d \geq 1$   
 -----  
 -----  
 -----  
 -----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 998292.205$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.32441$

$\nu_u = 0.00051441$

$d = 0.8 * h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $\text{Col},j1 = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $\text{Col},j2 = 1.00$

$s/d = 0.16666667$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$  is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $\text{Col},c1 = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $\text{Col},c2 = 1.00$

$s/d = 0.56818182$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 998292.205$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$   
 $\mu_u = 13.32496$   
 $V_u = 0.00051441$   
 $d = 0.8 \cdot h = 600.00$   
 $Nu = 16273.616$   
 $Ag = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{sjacket} + V_{s,core} = 881489.011$   
 where:  
 $V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$   
 $V_{sj1} = 279252.68$  is calculated for section web jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{sj1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.3125$   
 $V_{sj2} = 523598.776$  is calculated for section flange jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{sj2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 0.00$   
 $s/d = 1.5625$   
 $V_{s,c2} = 78637.555$  is calculated for section flange core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

-----  
 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
 At local axis: 2

-----  
 Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1  
 At local axis: 3  
 Integration Section: (a)  
 Section Type: rcjics

Constant Properties

-----  
 Knowledge Factor,  $\phi = 1.00$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
Max Height,  $H_{max} = 750.00$   
Min Height,  $H_{min} = 400.00$   
Max Width,  $W_{max} = 750.00$   
Min Width,  $W_{min} = 400.00$   
Jacket Thickness,  $t_j = 100.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d >= 1$ )  
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -1.5711E+007$   
Shear Force,  $V_2 = -5216.58$   
Shear Force,  $V_3 = 95.78147$   
Axial Force,  $F = -16801.96$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 2208.54$   
-Middle:  $A_{sc,mid} = 2007.478$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,jacket} = 829.3805$   
-Compression:  $A_{sc,com,jacket} = 1746.726$   
-Middle:  $A_{sc,mid,jacket} = 1545.664$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,core} = 307.8761$   
-Compression:  $A_{sc,com,core} = 461.8141$   
-Middle:  $A_{sc,mid,core} = 461.8141$   
Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = \phi_u = 0.03788633$   
 $\phi_u = \phi_y + \phi_p = 0.03788633$

- Calculation of  $\phi_y$  -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.00429487$  ((4.29), Biskinis Phd))  
 $M_y = 6.1992E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) =  $3011.833$   
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$   
factor = 0.30  
 $A_g = 440000.00$   
Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16801.96$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$

$y_{\text{ten}} = 4.6432800\text{E-}006$

with  $f_y = 529.9948$

$d = 707.00$

$y = 0.19276996$

$A = 0.01015554$

$B = 0.00446595$

with  $p_t = 0.00434791$

$p_c = 0.00416509$

$p_v = 0.00378591$

$N = 16801.96$

$b = 750.00$

" = 0.06082037

$y_{\text{comp}} = 1.6222985\text{E-}005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.1918145$

$A = 0.01002374$

$B = 0.00440616$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03359146$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/d \geq 1$

shear control ratio  $V_y E / V_{CoI} O E = 1.11182$

$d = d_{\text{external}} = 707.00$

$s = s_{\text{external}} = 0.00$

-  $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$

jacket:  $s_1 = A_{v1} * L_{\text{stir1}} / (s_1 * A_g) = 0.00367709$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core:  $s_2 = A_{v2} * L_{\text{stir2}} / (s_2 * A_g) = 0.00067082$

$A_{v2} = 50.26548$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_2 = 250.00$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$N_{UD} = 16801.96$

$A_g = 440000.00$

$f_{cE} = (f_{c_{\text{jacket}}} * \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} * \text{Area}_{\text{core}}) / \text{section\_area} = 27.68182$

$f_{yE} = (f_{y_{\text{ext\_Long\_Reinf}}} * \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} * \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area\_Tot\_Long\_Rein} = 529.9948$

$f_{yE} = (f_{y_{\text{ext\_Trans\_Reinf}}} * s_1 + f_{y_{\text{int\_Trans\_Reinf}}} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = \text{Area\_Tot\_Long\_Rein} / (b * d) = 0.01009575$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (a)

## Calculation No. 13

column C1, Floor 1

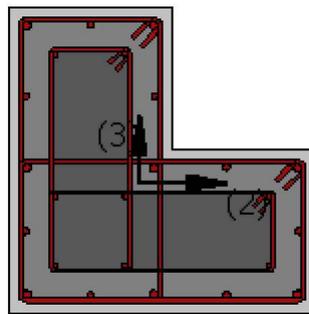
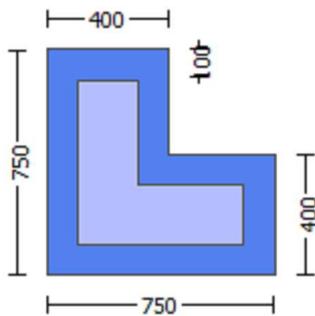
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity  $VR_d$

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjlc

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.4444$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -1.5711E+007$

Shear Force,  $V_a = -5216.58$

EDGE -B-

Bending Moment,  $M_b = 57815.565$

Shear Force,  $V_b = 5216.58$

BOTH EDGES

Axial Force,  $F = -16801.96$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 1137.257$

-Compression:  $As_{c,com} = 2208.54$

-Middle:  $As_{mid} = 2007.478$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 1.0165E+006$

$V_n ((10.3), ASCE 41-17) = knl * V_{CoI} = 1.0165E+006$

$V_{CoI} = 1.0165E+006$

$knl = 1.00$

$displacement\_ductility\_demand = 0.03829001$

-----  
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:  $f'_c = (f'_c\_jacket * Area\_jacket + f'_c\_core * Area\_core) / Area\_section = 21.31818$ , but  $f_c^{0.5} < = 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 57815.565$

$V_u = 5216.58$

$d = 0.8 * h = 600.00$

$N_u = 16801.96$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 793340.11$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$

Vs,j1 = 251327.412 is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

Vs,j1 is multiplied by Col,j1 = 1.00

$$s/d = 0.3125$$

Vs,j2 = 471238.898 is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

Vs,j2 is multiplied by Col,j2 = 1.00

$$s/d = 0.16666667$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$$

Vs,c1 = 0.00 is calculated for section web core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

Vs,c1 is multiplied by Col,c1 = 0.00

$$s/d = 1.5625$$

Vs,c2 = 70773.799 is calculated for section flange core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 400.00$$

$$s = 250.00$$

Vs,c2 is multiplied by Col,c2 = 1.00

$$s/d = 0.56818182$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 736127.561$

$$b_w = 400.00$$

-----  
displacement\_ductility\_demand is calculated as  $\phi / y$

- Calculation of  $\phi / y$  for END B -  
for rotation axis 3 and integ. section (b)

-----  
From analysis, chord rotation  $\theta = 1.6380465E-005$

$$y = (M_y * L_s / 3) / E_{eff} = 0.0004278 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 6.1992E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 300.00$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.4491E+014$$

$$\text{factor} = 0.30$$

$$A_g = 440000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182$$

$$N = 16801.96$$

$$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$$

-----  
Calculation of Yielding Moment  $M_y$

-----  
Calculation of  $\phi / y$  and  $M_y$  according to Annex 7 -

-----  
Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

$$\text{flange width, } b = 750.00$$

$$\text{web width, } b_w = 400.00$$

$$\text{flange thickness, } t = 400.00$$

$$y = \text{Min}(y_{ten}, y_{com})$$

$$y_{ten} = 4.6432800E-006$$

$$\text{with } f_y = 529.9948$$

$$d = 707.00$$

$$y = 0.19276996$$

$A = 0.01015554$   
 $B = 0.00446595$   
 with  $pt = 0.00214476$   
 $pc = 0.00416509$   
 $pv = 0.00378591$   
 $N = 16801.96$   
 $b = 750.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.6222985E-005$   
 with  $fc = 33.00$   
 $E_c = 26999.444$   
 $y = 0.1918145$   
 $A = 0.01002374$   
 $B = 0.00440616$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 2

Integration Section: (b)

## Calculation No. 14

column C1, Floor 1

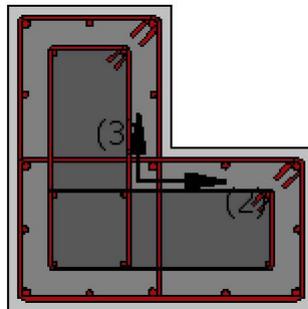
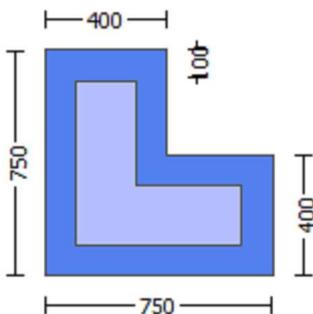
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_u$ )

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)  
Section Type: rcjcs

Constant Properties

-----  
Knowledge Factor,  $\gamma = 1.00$   
Mean strength values are used for both shear and moment calculations.  
Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, min} > 1$ )

No FRP Wrapping

-----  
Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{slt} = 0.00$

-Compression:  $A_{slc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 2208.54$

-Middle:  $A_{sl,mid} = 2007.478$

-----  
-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$

with

$$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6649E+009$$

$M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6649E+009$$

$M_{u2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 5.0126992E-005$$

$$M_u = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01155629$$

$$\text{we (5.4c)} = 0.04056485$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase1} * A_{ext} + \text{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\text{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$\text{ase2} (>= \text{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$\text{psh}_{,min} * F_{ywe} = \text{Min}(\text{psh}_{,x} * F_{ywe}, \text{psh}_{,y} * F_{ywe}) = 2.92621$$

$$\text{psh}_{,x} * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 2.92621$$

$$\text{psh}_1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\text{psh}_2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

psh<sub>y</sub>\*Fywe = psh<sub>1</sub>\*Fywe<sub>1</sub>+ps<sub>2</sub>\*Fywe<sub>2</sub> = 2.92621  
psh<sub>1</sub> ((5.4d), TBDY) = Lstir<sub>1</sub>\*Astir<sub>1</sub>/(Asec\*s<sub>1</sub>) = 0.00367709  
Lstir<sub>1</sub> (Length of stirrups along X) = 2060.00  
Astir<sub>1</sub> (stirrups area) = 78.53982  
psh<sub>2</sub> ((5.4d), TBDY) = Lstir<sub>2</sub>\*Astir<sub>2</sub>/(Asec\*s<sub>2</sub>) = 0.00067082  
Lstir<sub>2</sub> (Length of stirrups along X) = 1468.00  
Astir<sub>2</sub> (stirrups area) = 50.26548

Asec = 440000.00

s<sub>1</sub> = 100.00

s<sub>2</sub> = 250.00

fywe<sub>1</sub> = 694.4444

fywe<sub>2</sub> = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y<sub>1</sub> = 0.0025

sh<sub>1</sub> = 0.008

ft<sub>1</sub> = 788.2136

fy<sub>1</sub> = 656.8447

su<sub>1</sub> = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

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/d)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>1</sub> = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

with Es<sub>1</sub> = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y<sub>2</sub> = 0.0025

sh<sub>2</sub> = 0.008

ft<sub>2</sub> = 798.4827

fy<sub>2</sub> = 665.4022

su<sub>2</sub> = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

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/d)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fs<sub>2</sub> = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es<sub>2</sub> = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

y<sub>v</sub> = 0.0025

sh<sub>v</sub> = 0.008

ft<sub>v</sub> = 794.9922

fy<sub>v</sub> = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*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<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered  
characteristic value fsyv = fsv/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/d)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Es<sub>v</sub> = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs<sub>1</sub>/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs<sub>2</sub>/fc) = 0.08398367

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$c_c (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04845844$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09533179$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.09705994$$

$$\mu_u = M_{Rc} (4.14) = 1.0958E+009$$

$$u = s_u (4.1) = 5.0126992E-005$$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_{u1}$ -

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu_u = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 2.92621$

-----  
 $psh_{,x} * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_{,y} * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.4444$   
 $fywe2 = 555.5556$   
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 798.4827$   
 $fy1 = 665.4022$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{,min} = lb/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

with  $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 788.2136$   
 $fy2 = 656.8447$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou_{,min} = lb/l_{b,min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$

with  $Es2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 794.9922$   
 $fyv = 662.4935$

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fsjacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

-----  
Calculation of ratio lb/d

-----  
Adequate Lap Length: lb/d >= 1  
-----  
-----

-----  
Calculation of Mu2+  
-----  
-----

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 5.0126992E-005

Mu = 1.0958E+009  
-----

with full section properties:

b = 750.00

d = 707.00

d' = 43.00

v = 0.00093001

N = 16273.616

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01155629

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01155629

we (5.4c) = 0.04056485

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.45746528

ase1 = Max(((Aconf,max1-AnoConf1)/Aconf,max1)\*(Aconf,min1/Aconf,max1),0) = 0.45746528

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1} ((5.4d), \text{TBDY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2} ((5.4d), \text{TBDY}) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o / l_{ou,min} = l_b / l_d = 1.00$

$su1 = 0.4 * esu1_{nominal} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered

characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 656.8447$

with  $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 798.4827$

$$f_y2 = 665.4022$$

$$s_u2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{s_u2,nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s_u2,nominal} = 0.08$ ,

For calculation of  $e_{s_u2,nominal}$  and  $y_2$ ,  $sh_2, ft_2, f_y2$ , it is considered  
characteristic value  $f_{s_y2} = f_{s_2}/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, f_y1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_2} = (f_{s,jacket} * A_{s_l,com,jacket} + f_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 665.4022$$

$$\text{with } E_{s_2} = (E_{s,jacket} * A_{s_l,com,jacket} + E_{s,core} * A_{s_l,com,core}) / A_{s_l,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$f_{t_v} = 794.9922$$

$$f_{y_v} = 662.4935$$

$$s_{u_v} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o/l_{o,u,min} = l_b/l_d = 1.00$$

$$s_{u_v} = 0.4 * e_{s_{u_v},nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $e_{s_{u_v},nominal} = 0.08$ ,

considering characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY

For calculation of  $e_{s_{u_v},nominal}$  and  $y_v$ ,  $sh_v, f_{t_v}, f_{y_v}$ , it is considered  
characteristic value  $f_{s_{y_v}} = f_{s_v}/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1, ft_1, f_y1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } f_{s_v} = (f_{s,jacket} * A_{s_l,mid,jacket} + f_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 662.4935$$

$$\text{with } E_{s_v} = (E_{s,jacket} * A_{s_l,mid,jacket} + E_{s,mid} * A_{s_l,mid,core}) / A_{s_l,mid} = 200000.00$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.04269004$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.08398367$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = A_{s_l,ten} / (b * d) * (f_{s_1} / f_c) = 0.04845844$$

$$2 = A_{s_l,com} / (b * d) * (f_{s_2} / f_c) = 0.09533179$$

$$v = A_{s_l,mid} / (b * d) * (f_{s_v} / f_c) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.09705994$$

$$\mu_u = M_{Rc} (4.14) = 1.0958E+009$$

$$u = s_u (4.1) = 5.0126992E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $\mu_u$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu_u = 1.6649E+009$$
  
-----

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i d_i / 6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i d_i / 6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 798.4827$$

$$fy1 = 665.4022$$

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is satisfied

---->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

$$u = su(4.1) = 6.3581565E-005$$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{Col}((10.3), \text{ASCE } 41-17) = knl * V_{Col0}$

$$V_{Col0} = 998292.205$$

$knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 13.31807$$

$$V_u = 0.00051441$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16273.616$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 881489.011$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 523598.776$  is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{sj1}$  is multiplied by  $Col_{j1} = 1.00$

$$s/d = 0.16666667$$

$V_{sj2} = 279252.68$  is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{sj2}$  is multiplied by  $Col_{j2} = 1.00$

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$  is multiplied by  $Col_{c1} = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c2}$  is multiplied by  $Col_{c2} = 0.00$

$$s/d = 1.5625$$

$V_f((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$$bw = 400.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 998292.205

kn1 = 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 = 27.68182, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 13.31753

Vu = 0.00051441

d = 0.8\*h = 600.00

Nu = 16273.616

Ag = 300000.00

From (11.5.4.8), ACI 318-14: Vs = Vs,jacket + Vs,core = 881489.011

where:

Vs,jacket = Vs,j1 + Vs,j2 = 802851.456

Vs,j1 = 523598.776 is calculated for section web jacket, with:

d = 600.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs,j1 is multiplied by Col,j1 = 1.00

s/d = 0.16666667

Vs,j2 = 279252.68 is calculated for section flange jacket, with:

d = 320.00

Av = 157079.633

fy = 555.5556

s = 100.00

Vs,j2 is multiplied by Col,j2 = 1.00

s/d = 0.3125

Vs,core = Vs,c1 + Vs,c2 = 78637.555

Vs,c1 = 78637.555 is calculated for section web core, with:

d = 440.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c1 is multiplied by Col,c1 = 1.00

s/d = 0.56818182

Vs,c2 = 0.00 is calculated for section flange core, with:

d = 160.00

Av = 100530.965

fy = 444.4444

s = 250.00

Vs,c2 is multiplied by Col,c2 = 0.00

s/d = 1.5625

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 838832.606

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
At Shear local axis: 2  
(Bending local axis: 3)  
Section Type: rcj1cs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, min} > 1$ )

No FRP Wrapping

-----  
Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 0.00$

-Compression:  $A_{sl,c} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 2208.54$

-Middle:  $A_{sl,mid} = 2007.478$

-----  
Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6649E+009$

$M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6649E+009$

$\mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

-----  
Calculation of  $\mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 5.0126992E-005$$

$$\mu = 1.0958E+009$$

-----  
with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093001$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.01155629$$

$$\mu_{cc} \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (\geq a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

$$cc(5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.04845844$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.09533179$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->  
v < vs,y2 - LHS eq.(4.5) is satisfied

$$su(4.9) = 0.09705994$$

$$Mu = MRc(4.14) = 1.0958E+009$$

$$u = su(4.1) = 5.0126992E-005$$

-----  
Calculation of ratio lb/l<sub>d</sub>

-----  
Adequate Lap Length: lb/l<sub>d</sub> >= 1  
-----

-----  
Calculation of Mu1-  
-----

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$Mu = 1.6649E+009$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$fc = 33.00$$

$$co(5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01155629$$

$$we(5.4c) = 0.04056485$$

$$ase((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.45746528$$

$$ase1 = \text{Max}(((Aconf,max1 - AnoConf1)/Aconf,max1)*(Aconf,min1/Aconf,max1), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max1 = 353600.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to bi<sup>2</sup>/6 as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2)*(Aconf,min2/Aconf,max2), 0) = 0.45746528$$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to bi<sup>2</sup>/6 as defined at (A.2).

$$psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.92621$$

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) = Lstir1\*Astir1/(Asec\*s1) = 0.00367709  
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 (5.4d) = Lstir2\*Astir2/(Asec\*s2) = 0.00067082  
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) = Lstir1\*Astir1/(Asec\*s1) = 0.00367709  
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) = Lstir2\*Astir2/(Asec\*s2) = 0.00067082  
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
considering characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
characteristic value  $fsv = fsv/1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 662.4935$

with  $Esv = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$

$1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.15746938$

$2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.08004382$

$v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.14250792$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 40.48856

$cc$  (5A.5, TBDY) = 0.00426926

$c =$  confinement factor = 1.22693

$1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.19346746$

$2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.09834213$

$v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

---->

$v < vs,y2$  - LHS eq.(4.5) is not satisfied

---->

$v < vs,c$  - RHS eq.(4.5) is satisfied

---->

$su$  (4.8) = 0.28813219

$Mu = MRc$  (4.15) = 1.6649E+009

$u = su$  (4.1) = 6.3581565E-005

Calculation of ratio  $lb/ld$

Adequate Lap Length:  $lb/ld \geq 1$

Calculation of  $Mu_{2+}$

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 5.0126992E-005$

$Mu = 1.0958E+009$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu^*$  = shear\_factor \* Max(  $cu$ ,  $cc$ ) = 0.01155629

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.01155629$

$we$  (5.4c) = 0.04056485

$ase$  ((5.4d), TBDY) =  $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

Aconf,min1 = 293525.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max1 by a length equal to half the clear spacing between external hoops.

AnoConf1 = 158733.333 is the unconfined external core area which is equal to  $bi^2/6$  as defined at (A.2).  
ase2 ( $\geq$  ase1) =  $\text{Max}(((Aconf,max2 - AnoConf2)/Aconf,max2) * (Aconf,min2/Aconf,max2), 0) = 0.45746528$

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

Aconf,max2 = 171264.00 is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

Aconf,min2 = 54741.00 is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area Aconf,max2 by a length equal to half the clear spacing between internal hoops.

AnoConf2 = 106242.667 is the unconfined internal core area which is equal to  $bi^2/6$  as defined at (A.2).  
psh,min\*Fywe =  $\text{Min}(psh,x*Fywe, psh,y*Fywe) = 2.92621$

psh\_x\*Fywe =  $psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
psh1 ((5.4d), TBDY) =  $Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 (5.4d) =  $Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y\*Fywe =  $psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
psh1 ((5.4d), TBDY) =  $Lstir1*Astir1/(Asec*s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $Lstir2*Astir2/(Asec*s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 =  $0.4*esu1\_nominal$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25*(lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 656.8447$

with Es1 =  $(Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

$$su_2 = 0.4 * esu_{2\_nominal} ((5.5), TBDY) = 0.032$$

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  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{jacket} * Asl_{,com,jacket} + fs_{core} * Asl_{,com,core}) / Asl_{,com} = 665.4022$$

$$\text{with } Es_2 = (Es_{jacket} * Asl_{,com,jacket} + Es_{core} * Asl_{,com,core}) / Asl_{,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 794.9922$$

$$fy_v = 662.4935$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{u,min} = lb/ld = 1.00$$

$$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered

characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs_v = (fs_{jacket} * Asl_{,mid,jacket} + fs_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 662.4935$$

$$\text{with } Es_v = (Es_{jacket} * Asl_{,mid,jacket} + Es_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 200000.00$$

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.04269004$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.08398367$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.07600422$$

and confined core properties:

$$b = 690.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 40.48856$$

$$cc (5A.5, TBDY) = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.04845844$$

$$2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.09533179$$

$$v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.08627414$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y_2}$  - LHS eq.(4.5) is satisfied

--->

$$su (4.9) = 0.09705994$$

$$\mu_u = MRc (4.14) = 1.0958E+009$$

$$u = su (4.1) = 5.0126992E-005$$

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$

-----  
Calculation of  $\mu_u$

-----  
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu_u = 1.6649E+009$$

-----  
with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 798.4827$$

$$fy1 = 665.4022$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou,min} = l_b / l_d = 1.00$$

$$su1 = 0.4 * e_{su1\_nominal} \text{ ((5.5), TBDY)} = 0.032$$

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  $fs1 = (fs\_jacket \cdot Asl,ten,jacket + fs\_core \cdot Asl,ten,core) / Asl,ten = 665.4022$

with  $Es1 = (Es\_jacket \cdot Asl,ten,jacket + Es\_core \cdot Asl,ten,core) / Asl,ten = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 788.2136$

$fy2 = 656.8447$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou,min = lb/lb,min = 1.00$

$su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$

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  $fs2 = (fs\_jacket \cdot Asl,com,jacket + fs\_core \cdot Asl,com,core) / Asl,com = 656.8447$

with  $Es2 = (Es\_jacket \cdot Asl,com,jacket + Es\_core \cdot Asl,com,core) / Asl,com = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 794.9922$

$fyv = 662.4935$

$su = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$

and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with

$Shear\_factor = 1.00$

$lo/lou,min = lb/ld = 1.00$

$su = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs\_jacket \cdot Asl,mid,jacket + fs\_mid \cdot Asl,mid,core) / Asl,mid = 662.4935$

with  $Es = (Es\_jacket \cdot Asl,mid,jacket + Es\_mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.15746938$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.08004382$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.14250792$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 40.48856$

$cc (5A.5, TBDY) = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.19346746$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.09834213$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 0.17508576$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$  - LHS eq.(4.5) is not satisfied

--->

$v < vs,c$  - RHS eq.(4.5) is satisfied

--->

$su (4.8) = 0.28813219$

$Mu = MRc (4.15) = 1.6649E+009$

$u = su (4.1) = 6.3581565E-005$

-----  
Calculation of ratio  $lb/ld$

-----  
Adequate Lap Length:  $lb/ld \geq 1$

-----  
-----  
-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$   
-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{Col} ((10.3), \text{ASCE } 41-17) = knl * V_{Col0}$

$V_{Col0} = 998292.205$

$knl = 1$  (zero step-static loading)

-----  
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
 $= 1$  (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} * \text{Area}_{jacket} + f'_{c,core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.32441$

$V_u = 0.00051441$

$d = 0.8 * h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 881489.011$

where:

$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $Col_{j1} = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $Col_{j2} = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$  is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $Col_{c1} = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $Col_{c2} = 1.00$

$s/d = 0.56818182$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$bw = 400.00$   
-----

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{Col} ((10.3), \text{ASCE } 41-17) = knl * V_{Col0}$

$V_{Col0} = 998292.205$

$knl = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 13.32496$   
 $V_u = 0.00051441$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16273.616$   
 $A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$   
 where:  
 $V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$   
 $V_{s,j1} = 279252.68$  is calculated for section web jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $\text{Col},j1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 555.5556$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $\text{Col},j2 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$   
 $V_{s,c1} = 0.00$  is calculated for section web core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $\text{Col},c1 = 0.00$   
 $s/d = 1.5625$   
 $V_{s,c2} = 78637.555$  is calculated for section flange core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 444.4444$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $\text{Col},c2 = 1.00$   
 $s/d = 0.56818182$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $b_w = 400.00$

-----  
 -----  
 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
 At local axis: 2

-----  
 -----  
 Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1  
 At local axis: 2  
 Integration Section: (b)  
 Section Type: rcjcs

Constant Properties

-----  
 Knowledge Factor,  $\phi = 1.00$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$   
Concrete Elasticity,  $E_c = 21019.039$   
Steel Elasticity,  $E_s = 200000.00$   
Max Height,  $H_{max} = 750.00$   
Min Height,  $H_{min} = 400.00$   
Max Width,  $W_{max} = 750.00$   
Min Width,  $W_{min} = 400.00$   
Jacket Thickness,  $t_j = 100.00$   
Cover Thickness,  $c = 25.00$   
Element Length,  $L = 3000.00$   
Primary Member  
Ribbed Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d >= 1$ )  
No FRP Wrapping

-----  
Stepwise Properties  
-----

Bending Moment,  $M = -89327.543$   
Shear Force,  $V_2 = 5216.58$   
Shear Force,  $V_3 = -95.78147$   
Axial Force,  $F = -16801.96$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5353.274$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 2208.54$   
-Middle:  $A_{st,mid} = 2007.478$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,jacket} = 829.3805$   
-Compression:  $A_{sc,com,jacket} = 1746.726$   
-Middle:  $A_{st,mid,jacket} = 1545.664$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten,core} = 307.8761$   
-Compression:  $A_{sc,com,core} = 461.8141$   
-Middle:  $A_{st,mid,core} = 461.8141$   
Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = * u = 0.03492137$   
 $u = y + p = 0.03492137$

-----  
- Calculation of  $y$  -  
-----

$y = (M_y * L_s / 3) / E_{eff} = 0.00132991$  ((4.29), Biskinis Phd))  
 $M_y = 6.1992E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 932.6182  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$   
factor = 0.30  
 $A_g = 440000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16801.96$   
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 4.8303E+014$   
-----  
-----

Calculation of Yielding Moment  $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 4.6432800\text{E-}006$$

with  $f_y = 529.9948$

$$d = 707.00$$

$$y = 0.19276996$$

$$A = 0.01015554$$

$$B = 0.00446595$$

$$\text{with } p_t = 0.00434791$$

$$p_c = 0.00416509$$

$$p_v = 0.00378591$$

$$N = 16801.96$$

$$b = 750.00$$

$$\rho = 0.06082037$$

$$y_{\text{comp}} = 1.6222985\text{E-}005$$

with  $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.1918145$$

$$A = 0.01002374$$

$$B = 0.00440616$$

$$\text{with } E_s = 200000.00$$

CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.03359146$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/d \geq 1$

shear control ratio  $V_y/E/ColOE = 1.11182$

$$d = d_{\text{external}} = 707.00$$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 \cdot t_f/b_w \cdot (f_{fe}/f_s) = 0.00434791$$

$$\text{jacket: } s_1 = A_{v1} \cdot L_{\text{stir1}} / (s_1 \cdot A_g) = 0.00367709$$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot L_{\text{stir2}} / (s_2 \cdot A_g) = 0.00067082$$

$A_{v2} = 50.26548$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

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.

$$N_{UD} = 16801.96$$

$$A_g = 440000.00$$

$$f_c E = (f_c \cdot \text{Area}_{\text{jacket}} + f_c \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 27.68182$$

$$f_y I_E = (f_y \cdot \text{ext\_Long\_Reinf} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_y \cdot \text{int\_Long\_Reinf} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 529.9948$$

$$f_y t_E = (f_y \cdot \text{ext\_Trans\_Reinf} \cdot s_1 + f_y \cdot \text{int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$$

$$\rho_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.01009575$$

$$b = 750.00$$

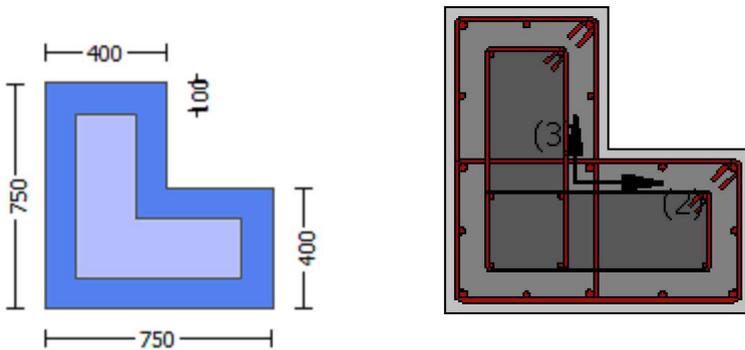
$$d = 707.00$$

$$f_{cE} = 27.68182$$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1  
At local axis: 2  
Integration Section: (b)

## Calculation No. 15

column C1, Floor 1  
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $V_{Rd}$   
Edge: End  
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcjics

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Primary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
Existing material of Primary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 400.00$   
Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of  $\gamma$  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,  $f_s = f_{sm} = 555.5556$

Existing Column

Existing material: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material: Steel Strength,  $f_s = f_{sm} = 444.4444$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{o,u,min} = l_b/l_d \geq 1$ )

No FRP Wrapping

-----  
Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -196550.732$

Shear Force,  $V_a = 95.78147$

EDGE -B-

Bending Moment,  $M_b = -89327.543$

Shear Force,  $V_b = -95.78147$

BOTH EDGES

Axial Force,  $F = -16801.96$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 0.00$

-Compression:  $A_{sl,c} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 2208.54$

-Middle:  $A_{sl,mid} = 2007.478$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 1.0165E+006$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 1.0165E+006$

$V_{CoI} = 1.0165E+006$

$k_n = 1.00$

displacement\_ductility\_demand = 2.2645048E-005

-----  
NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + \phi V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----  
= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 21.31818$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 89327.543$

$V_u = 95.78147$

$d = 0.8 \cdot h = 600.00$

$N_u = 16801.96$

$A_g = 300000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s,jacket} + V_{s,core} = 793340.11$   
 where:  
 $V_{s,jacket} = V_{s,j1} + V_{s,j2} = 722566.31$   
 $V_{s,j1} = 471238.898$  is calculated for section web jacket, with:  
 $d = 600.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.16666667$   
 $V_{s,j2} = 251327.412$  is calculated for section flange jacket, with:  
 $d = 320.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j2}$  is multiplied by  $Col,j2 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,core} = V_{s,c1} + V_{s,c2} = 70773.799$   
 $V_{s,c1} = 70773.799$  is calculated for section web core, with:  
 $d = 440.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 1.00$   
 $s/d = 0.56818182$   
 $V_{s,c2} = 0.00$  is calculated for section flange core, with:  
 $d = 160.00$   
 $A_v = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c2}$  is multiplied by  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440:  $V_s + V_f \leq 736127.561$   
 $bw = 400.00$

-----  
 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  $\theta = 3.0115957E-008$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00132991$  ((4.29), Biskinis Phd))  
 $M_y = 6.1992E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 932.6182  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$   
 $factor = 0.30$   
 $A_g = 440000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16801.96$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

-----  
 Calculation of Yielding Moment  $M_y$

-----  
 Calculation of  $\phi / y$  and  $M_y$  according to Annex 7 -

-----  
 Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:  
 flange width,  $b = 750.00$   
 web width,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

-----  
 $y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 4.6432800E-006$

with  $f_y = 529.9948$

$d = 707.00$

$y = 0.19276996$

$A = 0.01015554$

$B = 0.00446595$

with  $pt = 0.00214476$

$pc = 0.00416509$

$pv = 0.00378591$

$N = 16801.96$

$b = 750.00$

" = 0.06082037

$y_{comp} = 1.6222985E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.1918145$

$A = 0.01002374$

$B = 0.00440616$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

## Calculation No. 16

column C1, Floor 1

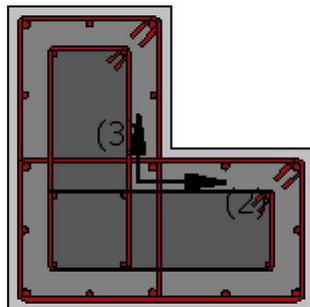
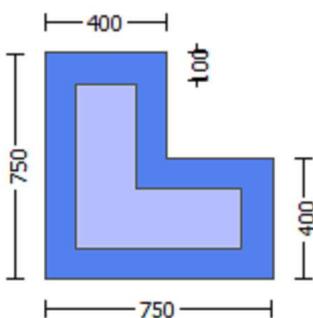
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta$ )

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 3  
(Bending local axis: 2)  
Section Type: rcjlc

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, min} >= 1$ )

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl} = 0.00$

-Compression:  $A_{slc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl, ten} = 1137.257$

-Compression:  $A_{sl, com} = 2208.54$

-Middle:  $A_{sl, mid} = 2007.478$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 1.11182$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$

with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6649E+009$   
 $M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $M_{u1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.6649E+009$   
 $M_{u2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination  
 $M_{u2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $M_{u1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 5.0126992E-005$

$M_u = 1.0958E+009$   
-----

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$f_c = 33.00$

$\alpha$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.01155629$

$\omega_e$  (5.4c) = 0.04056485

$\alpha_{se}$  ((5.4d), TBDY) =  $(\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.45746528$

$\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length

equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$\alpha_{se2} (> \alpha_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization

of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length

equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$   
-----

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

psh2 (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

psh\_y \* Fywe = psh1 \* Fywe1 + ps2 \* Fywe2 = 2.92621  
psh1 ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00426926

c = confinement factor = 1.22693

y1 = 0.0025

sh1 = 0.008

ft1 = 788.2136

fy1 = 656.8447

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 =  $0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $Min(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$

with Es1 =  $(Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

y2 = 0.0025

sh2 = 0.008

ft2 = 798.4827

fy2 = 665.4022

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $Min(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 665.4022$

with Es2 =  $(Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv =  $0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv, ftv, fyv, it is considered

characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $Min(1, 1.25 * (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{sv} = (f_{s,jacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 662.4935$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04269004$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.08398367$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.07600422$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.04845844$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.09533179$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.09705994$   
 $Mu = MRc (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $l_b/d$

-----  
 Adequate Lap Length:  $l_b/d \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu1$ -  
 -----  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$   
 $Mu = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$

$f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.01155629$

we (5.4c)  $= 0.04056485$

$ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along X) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along X) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.4444$   
 $fywe2 = 555.5556$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 798.4827$   
 $fy1 = 665.4022$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su1 = 0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (f_{s,jacket} * A_{sl,ten,jacket} + f_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 665.4022$

with  $Es1 = (E_{s,jacket} * A_{sl,ten,jacket} + E_{s,core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 788.2136$   
 $fy2 = 656.8447$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

$su2 = 0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (f_{s,jacket} * A_{sl,com,jacket} + f_{s,core} * A_{sl,com,core}) / A_{sl,com} = 656.8447$

with  $Es2 = (E_{s,jacket} * A_{sl,com,jacket} + E_{s,core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

-----  
Calculation of ratio lb/ld

-----  
Adequate Lap Length: lb/ld >= 1  
-----  
-----  
-----

-----  
Calculation of Mu2+  
-----  
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-----

-----  
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 5.0126992E-005

Mu = 1.0958E+009  
-----

with full section properties:

b = 750.00

d = 707.00

d' = 43.00

v = 0.00093001

N = 16273.616

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01155629

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01155629

$$w_e (5.4c) = 0.04056485$$

$$ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$$

$$ase1 = \text{Max}(((A_{conf,max1} - A_{noconf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noconf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noconf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - A_{noconf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noconf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noconf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.A.5), TBDY), TBDY: c_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 788.2136$$

$$fy1 = 656.8447$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o / l_{ou,min} = l_b / l_d = 1.00$$

$$su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , it is considered

characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 656.8447$$

with  $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 798.4827$   
 $fy_2 = 665.4022$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 1.00$   
 $su_2 = 0.4 \cdot esu_2,nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_2,nominal = 0.08$ ,  
 For calculation of  $esu_2,nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fs_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 665.4022$   
 with  $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 794.9922$   
 $fy_v = 662.4935$   
 $su_v = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 1.00$   
 $su_v = 0.4 \cdot esuv,nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv,nominal = 0.08$ ,  
 considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv,nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 662.4935$   
 with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04269004$   
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.08398367$   
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.07600422$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.04845844$   
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.09533179$   
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_s, y_2$  - LHS eq.(4.5) is satisfied

---->

$su (4.9) = 0.09705994$   
 $Mu = MRc (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $lb/ld$

-----  
 Adequate Lap Length:  $lb/ld \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu_2$ -  
 -----  
 -----

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 6.3581565E-005$$

$$\mu = 1.6649E+009$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$\omega (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01155629$$

$$w_e (5.4c) = 0.04056485$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$  - RHS eq.(4.5) is satisfied

--->

$$\mu (4.8) = 0.28813219$$

$$\mu = M/R_c (4.15) = 1.6649E+009$$

$$u = \mu (4.1) = 6.3581565E-005$$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 998292.205$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

-----  
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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/V_d = 4.00$$

$$\mu_u = 13.31807$$

$$V_u = 0.00051441$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16273.616$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

where:

$$V_{s,jacket} = V_{s,j1} + V_{s,j2} = 802851.456$$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{s,j1}$  is multiplied by  $Col_{j1} = 1.00$

$$s/d = 0.16666667$$

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 555.5556$$

$$s = 100.00$$

$V_{s,j2}$  is multiplied by  $Col_{j2} = 1.00$

$$s/d = 0.3125$$

$$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

$$d = 440.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c1}$  is multiplied by  $Col_{c1} = 1.00$

$$s/d = 0.56818182$$

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

$$d = 160.00$$

$$A_v = 100530.965$$

$$f_y = 444.4444$$

$$s = 250.00$$

$V_{s,c2}$  is multiplied by  $Col_{c2} = 0.00$

$$s/d = 1.5625$$

$$V_f ((11-3)-(11.4), ACI 440) = 0.00$$

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 838832.606$$

bw = 400.00

Calculation of Shear Strength at edge 2, Vr2 = 998292.205

Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 998292.205

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '

where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00

Mu = 13.31753

Vu = 0.00051441

d = 0.8 \* h = 600.00

Nu = 16273.616

Ag = 300000.00

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 523598.776$  is calculated for section web jacket, with:

d = 600.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 100.00

$V_{s,j1}$  is multiplied by Col,j1 = 1.00

s/d = 0.16666667

$V_{s,j2} = 279252.68$  is calculated for section flange jacket, with:

d = 320.00

$A_v = 157079.633$

$f_y = 555.5556$

s = 100.00

$V_{s,j2}$  is multiplied by Col,j2 = 1.00

s/d = 0.3125

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 78637.555$  is calculated for section web core, with:

d = 440.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c1}$  is multiplied by Col,c1 = 1.00

s/d = 0.56818182

$V_{s,c2} = 0.00$  is calculated for section flange core, with:

d = 160.00

$A_v = 100530.965$

$f_y = 444.4444$

s = 250.00

$V_{s,c2}$  is multiplied by Col,c2 = 0.00

s/d = 1.5625

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

bw = 400.00

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.4444$

Existing Column

Existing material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 555.5556$

#####

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Mean Confinement Factor overall section = 1.22693

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou, min} > 1$ )

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -0.00051441$

EDGE -B-

Shear Force,  $V_b = 0.00051441$

BOTH EDGES

Axial Force,  $F = -16273.616$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st, ten} = 1137.257$

-Compression:  $A_{sl, com} = 2208.54$

-Middle:  $A_{sl, mid} = 2007.478$

Calculation of Shear Capacity ratio,  $V_e/V_r = 1.11182$

Member Controlled by Shear ( $V_e/V_r > 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 1.1099E+006$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6649E+009$

$M_{u1+} = 1.0958E+009$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction

which is defined for the static loading combination

$Mu_{1-} = 1.6649E+009$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr_2 = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.6649E+009$

$Mu_{2+} = 1.0958E+009$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.6649E+009$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

-----  
Calculation of  $Mu_{1+}$   
-----

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 5.0126992E-005$

$Mu = 1.0958E+009$   
-----

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093001$

$N = 16273.616$

$f_c = 33.00$

$\phi_{co} (5A.5, TBDY) = 0.002$

Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01155629$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_{cu} = 0.01155629$

we (5.4c) = 0.04056485

$\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.45746528$

$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$\phi_{ase2} (>= \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.92621$   
-----

$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$

$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548  
-----

$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$

$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$   
-----

Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
psh2 ((5.4d), TBDY) = Lstir2\*Astir2/(Asec\*s2) = 0.00067082  
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
Asec = 440000.00  
s1 = 100.00  
s2 = 250.00

fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 788.2136  
fy1 = 656.8447  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 656.8447

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025  
sh2 = 0.008  
ft2 = 798.4827  
fy2 = 665.4022  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 665.4022

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/d = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.04269004

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08398367

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.07600422

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 40.48856$   
 $cc (5A.5, TBDY) = 0.00426926$   
 $c = \text{confinement factor} = 1.22693$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.04845844$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.09533179$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.08627414$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.09705994$   
 $Mu = MRc (4.14) = 1.0958E+009$   
 $u = su (4.1) = 5.0126992E-005$

-----  
 Calculation of ratio  $l_b/d$

-----  
 Adequate Lap Length:  $l_b/d \geq 1$   
 -----  
 -----

-----  
 Calculation of  $Mu_1$ -  
 -----

-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$   
 $Mu = 1.6649E+009$

-----  
 with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174378$   
 $N = 16273.616$   
 $f_c = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01155629$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01155629$   
 $we (5.4c) = 0.04056485$   
 $ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.45746528$   
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1})/A_{conf,max1}) * (A_{conf,min1}/A_{conf,max1}), 0) = 0.45746528$   
 The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).  
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."  
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.  
 $A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.  
 $A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.  
 $A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $ase2 (\geq ase1) = \text{Max}(((A_{conf,max2} - A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$   
 The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).  
 The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988) "Theoretical Stress-Strain Model for Confined Concrete."  
 J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.  
 $A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.  
 $A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$AnoConf2 = 106242.667$  is the unconfined internal core area which is equal to  $bi^2/6$  as defined at (A.2).  
 $psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 2.92621$

-----  
 $psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along Y) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along Y) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
 $psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
Lstir1 (Length of stirrups along X) = 2060.00  
Astir1 (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $Lstir2 * Astir2 / (Asec * s2) = 0.00067082$   
Lstir2 (Length of stirrups along X) = 1468.00  
Astir2 (stirrups area) = 50.26548

-----  
Asec = 440000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.4444  
fywe2 = 555.5556  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00426926  
c = confinement factor = 1.22693

y1 = 0.0025  
sh1 = 0.008  
ft1 = 798.4827  
fy1 = 665.4022  
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 =  $0.4 * esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 665.4022$

with Es1 =  $(Es_{jacket} * Asl_{ten,jacket} + Es_{core} * Asl_{ten,core}) / Asl_{ten} = 200000.00$

y2 = 0.0025  
sh2 = 0.008  
ft2 = 788.2136  
fy2 = 656.8447  
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 =  $0.4 * esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2, ft2, fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 =  $(fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 656.8447$

with Es2 =  $(Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$

yv = 0.0025  
shv = 0.008  
ftv = 794.9922  
fyv = 662.4935  
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lo<sub>u,min</sub> = lb/d = 1.00

su<sub>v</sub> = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fs<sub>yv</sub> = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and y<sub>v</sub>, sh<sub>v</sub>,ft<sub>v</sub>,fy<sub>v</sub>, it is considered characteristic value fs<sub>yv</sub> = fsv/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/d)<sup>2/3</sup>), from 10.3.5, ASCE 41-17.

with fsv = (fs<sub>jacket</sub>\*Asl<sub>mid,jacket</sub> + fs<sub>mid</sub>\*Asl<sub>mid,core</sub>)/Asl<sub>mid</sub> = 662.4935

with Es<sub>v</sub> = (Es<sub>jacket</sub>\*Asl<sub>mid,jacket</sub> + Es<sub>mid</sub>\*Asl<sub>mid,core</sub>)/Asl<sub>mid</sub> = 200000.00

1 = Asl<sub>ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.15746938

2 = Asl<sub>com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.08004382

v = Asl<sub>mid</sub>/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl<sub>ten</sub>/(b\*d)\*(fs<sub>1</sub>/fc) = 0.19346746

2 = Asl<sub>com</sub>/(b\*d)\*(fs<sub>2</sub>/fc) = 0.09834213

v = Asl<sub>mid</sub>/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < v<sub>s,y2</sub> - LHS eq.(4.5) is not satisfied

--->

v < v<sub>s,c</sub> - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu<sub>2+</sub>

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 5.0126992E-005

Mu = 1.0958E+009

with full section properties:

b = 750.00

d = 707.00

d' = 43.00

v = 0.00093001

N = 16273.616

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01155629

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01155629

we (5.4c) = 0.04056485

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.45746528

ase1 = Max(((Aconf,max1 - AnoConf1)/Aconf,max1)\*(Aconf,min1/Aconf,max1),0) = 0.45746528

The definitions of AnoConf, Aconf,min and Aconf,max are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the external perimeter hoops.  
 $A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noconf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noconf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

The definitions of  $A_{noconf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noconf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).  
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$

-----  
 $p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  (5.4d) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along X) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 788.2136$

$fy1 = 656.8447$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$

$su1 = 0.4 * e_{su1,nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1,nominal} = 0.08$ ,

For calculation of  $e_{su1,nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $f_{s1} = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 656.8447$

with  $E_{s1} = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 798.4827$

$fy2 = 665.4022$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,u,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,

For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 665.4022$

with  $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 794.9922$

$fy_v = 662.4935$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$l_o/l_{o,u,min} = l_b/l_d = 1.00$

$suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 662.4935$

with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$

$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.04269004$

$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.08398367$

$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.07600422$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 40.48856$

$cc (5A.5, TBDY) = 0.00426926$

$c = \text{confinement factor} = 1.22693$

$1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.04845844$

$2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.09533179$

$v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.08627414$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.09705994$

$Mu = MRc (4.14) = 1.0958E+009$

$u = su (4.1) = 5.0126992E-005$

-----  
Calculation of ratio  $l_b/l_d$

-----  
Adequate Lap Length:  $l_b/l_d \geq 1$

-----  
Calculation of  $Mu_2$ -

-----  
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 6.3581565E-005$

$Mu = 1.6649E+009$

-----  
with full section properties:

$b = 400.00$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174378$$

$$N = 16273.616$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01155629$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01155629$$

$$w_e \text{ (5.4c)} = 0.04056485$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the external perimeter hoops.

$A_{conf,min1} = 293525.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max1}$  by a length equal to half the clear spacing between external hoops.

$A_{noConf1} = 158733.333$  is the unconfined external core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$a_{se2} (> a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

The definitions of  $A_{noConf}$ ,  $A_{conf,min}$  and  $A_{conf,max}$  are derived from generalization of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max2} = 171264.00$  is the confined core area at levels of member with hoops and

is calculated as the area of core enclosed by the center lines of the internal perimeter hoops.

$A_{conf,min2} = 54741.00$  is the confined core area at midway between the levels of hoops and

is calculated by reducing all the dimensions of the area  $A_{conf,max2}$  by a length equal to half the clear spacing between internal hoops.

$A_{noConf2} = 106242.667$  is the unconfined internal core area which is equal to  $b_i^2/6$  as defined at (A.2).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1} \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$p_{sh2} \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00426926$$

$$c = \text{confinement factor} = 1.22693$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 798.4827$$

$$fy1 = 665.4022$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 665.4022

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 788.2136

fy2 = 656.8447

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 656.8447

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 794.9922

fyv = 662.4935

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 662.4935

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.15746938

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.08004382

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.14250792

and confined core properties:

b = 340.00

d = 677.00

d' = 13.00

fcc (5A.2, TBDY) = 40.48856

cc (5A.5, TBDY) = 0.00426926

c = confinement factor = 1.22693

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.19346746

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.09834213

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.17508576

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is satisfied

--->

su (4.8) = 0.28813219

Mu = MRc (4.15) = 1.6649E+009

u = su (4.1) = 6.3581565E-005

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998292.205$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998292.205$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{ColO}$

$V_{ColO} = 998292.205$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.32441$

$\nu_u = 0.00051441$

$d = 0.8 * h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{sjacket} + V_{s,core} = 881489.011$

where:

$V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$

$V_{sj1} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{sj1}$  is multiplied by  $Col_{j1} = 1.00$

$s/d = 0.3125$

$V_{sj2} = 523598.776$  is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{sj2}$  is multiplied by  $Col_{j2} = 1.00$

$s/d = 0.16666667$

$V_{s,core} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$  is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $Col_{c1} = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $Col_{c2} = 1.00$

$s/d = 0.56818182$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998292.205$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{ColO}$

$V_{ColO} = 998292.205$

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 13.32496$

$V_u = 0.00051441$

$d = 0.8 \cdot h = 600.00$

$N_u = 16273.616$

$A_g = 300000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s,\text{jacket}} + V_{s,\text{core}} = 881489.011$

where:

$V_{s,\text{jacket}} = V_{s,j1} + V_{s,j2} = 802851.456$

$V_{s,j1} = 279252.68$  is calculated for section web jacket, with:

$d = 320.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j1}$  is multiplied by  $\text{Col},j1 = 1.00$

$s/d = 0.3125$

$V_{s,j2} = 523598.776$  is calculated for section flange jacket, with:

$d = 600.00$

$A_v = 157079.633$

$f_y = 555.5556$

$s = 100.00$

$V_{s,j2}$  is multiplied by  $\text{Col},j2 = 1.00$

$s/d = 0.16666667$

$V_{s,\text{core}} = V_{s,c1} + V_{s,c2} = 78637.555$

$V_{s,c1} = 0.00$  is calculated for section web core, with:

$d = 160.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c1}$  is multiplied by  $\text{Col},c1 = 0.00$

$s/d = 1.5625$

$V_{s,c2} = 78637.555$  is calculated for section flange core, with:

$d = 440.00$

$A_v = 100530.965$

$f_y = 444.4444$

$s = 250.00$

$V_{s,c2}$  is multiplied by  $\text{Col},c2 = 1.00$

$s/d = 0.56818182$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$b_w = 400.00$

End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjlc

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Primary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Primary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Primary Member: Steel Strength,  $f_s = f_{sm} = 444.4444$

Concrete Elasticity,  $E_c = 21019.039$

Steel Elasticity,  $E_s = 200000.00$

Max Height,  $H_{max} = 750.00$

Min Height,  $H_{min} = 400.00$

Max Width,  $W_{max} = 750.00$

Min Width,  $W_{min} = 400.00$

Jacket Thickness,  $t_j = 100.00$

Cover Thickness,  $c = 25.00$

Element Length,  $L = 3000.00$

Primary Member

Ribbed Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_b/d >= 1$ )

No FRP Wrapping

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Stepwise Properties

Bending Moment,  $M = 57815.565$

Shear Force,  $V_2 = 5216.58$

Shear Force,  $V_3 = -95.78147$

Axial Force,  $F = -16801.96$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{sl,t} = 0.00$

-Compression:  $A_{sl,c} = 5353.274$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten} = 1137.257$

-Compression:  $A_{sl,com} = 2208.54$

-Middle:  $A_{sl,mid} = 2007.478$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten,jacket} = 829.3805$

-Compression:  $A_{sl,com,jacket} = 1746.726$

-Middle:  $A_{sl,mid,jacket} = 1545.664$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{sl,ten,core} = 307.8761$

-Compression:  $A_{sl,com,core} = 461.8141$

-Middle:  $A_{sl,mid,core} = 461.8141$

Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

-----  
Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = * u = 0.03401926$

$u = y + p = 0.03401926$

-----  
- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.0004278$  ((4.29), Biskinis Phd))

$M_y = 6.1992E+008$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 300.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.4491E+014$

factor = 0.30

$A_g = 440000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$

$N = 16801.96$

$$E_c I_g = E_{c\_jacket} I_{g\_jacket} + E_{c\_core} I_{g\_core} = 4.8303E+014$$

Calculation of Yielding Moment  $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 4.6432800E-006$$

with  $f_y = 529.9948$

$$d = 707.00$$

$$y = 0.19276996$$

$$A = 0.01015554$$

$$B = 0.00446595$$

$$\text{with } p_t = 0.00434791$$

$$p_c = 0.00416509$$

$$p_v = 0.00378591$$

$$N = 16801.96$$

$$b = 750.00$$

$$\rho = 0.06082037$$

$$y_{\text{comp}} = 1.6222985E-005$$

with  $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.1918145$$

$$A = 0.01002374$$

$$B = 0.00440616$$

$$\text{with } E_s = 200000.00$$

CONFIRMATION:  $y = 0.19276996 < t/d$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.03359146$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/d \geq 1$

$$\text{shear control ratio } V_y E / V_{CoI} E = 1.11182$$

$$d = d_{\text{external}} = 707.00$$

$$s = s_{\text{external}} = 0.00$$

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$$

$$\text{jacket: } s_1 = A_{v1} * L_{\text{stir1}} / (s_1 * A_g) = 0.00367709$$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir1}} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * L_{\text{stir2}} / (s_2 * A_g) = 0.00067082$$

$A_{v2} = 50.26548$ , is the area of every stirrup parallel to loading (shear) direction

$L_{\text{stir2}} = 1468.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$$s_2 = 250.00$$

The term  $2 * t_f / b_w * (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 * t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$$N_{UD} = 16801.96$$

$$A_g = 440000.00$$

$$f_{cE} = (f_{c\_jacket} * \text{Area}_{\text{jacket}} + f_{c\_core} * \text{Area}_{\text{core}}) / \text{section\_area} = 27.68182$$

$$f_{yE} = (f_{y\_ext\_Long\_Reinf} * \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y\_int\_Long\_Reinf} * \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 529.9948$$

$f_{tE} = (f_{y\_ext\_Trans\_Reinf} \cdot s_1 + f_{y\_int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$   
 $\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.01009575$   
 $b = 750.00$   
 $d = 707.00$   
 $f_{cE} = 27.68182$

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End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1  
At local axis: 3  
Integration Section: (b)