

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

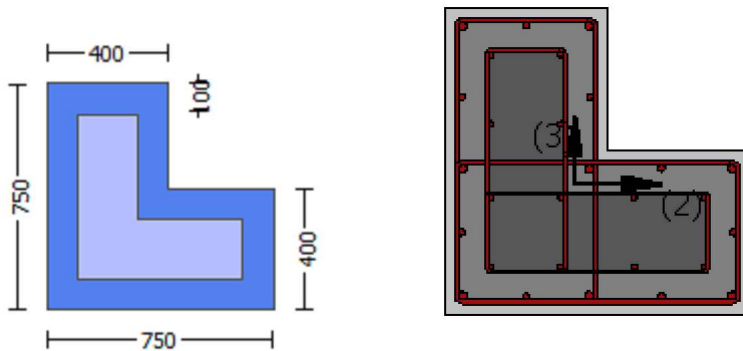
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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: rcjls

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$   
Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -2.3735E+007$   
Shear Force,  $V_a = -7874.616$   
EDGE -B-  
Bending Moment,  $M_b = 105242.575$   
Shear Force,  $V_b = 7874.616$   
BOTH EDGES  
Axial Force,  $F = -17081.857$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 2362.478$   
-Middle:  $A_{sl,mid} = 2469.292$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = V_n = 876340.192$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n V_{Col0} = 876340.192$   
 $V_{Col} = 876340.192$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.03712301

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:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 21.31818$ , but  $f_c'^{0.5} < =$

8.3 MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 2.3735E+007$$

$$V_u = 7874.616$$

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

$$N_u = 17081.857$$

$$A_g = 300000.00$$

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

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 722566.31$$

$V_{sj1} = 251327.412$  is calculated for section web jacket, with:

$$d = 320.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

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

$$s/d = 0.3125$$

$V_{sj2} = 471238.898$  is calculated for section flange jacket, with:

$$d = 600.00$$

$$A_v = 157079.633$$

$$f_y = 500.00$$

$$s = 100.00$$

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

$$s/d = 0.16666667$$

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

$V_{s,c1} = 0.00$  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  $Col,c2 = 1.00$

$$s/d = 0.56818182$$

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

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

$$bw = 400.00$$

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

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

From analysis, chord rotation  $\theta_r = 9.5103078E-005$

$$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00256184 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 3.6949E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 \cdot L \text{ and } L_s < 2 \cdot L) = 3014.102$$

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

$$\text{factor} = 0.30$$

$$A_g = 440000.00$$

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

$$N = 17081.857$$

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

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta_u$  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,  $t = 400.00$

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

$y_{\text{ten}} = 2.5827649\text{E-}006$

with  $((10.1), \text{ASCE 41-17}) f_y = \text{Min}(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with  $p_t = 0.00214476$

$p_c = 0.0044554$

$p_v = 0.00465684$

$N = 17081.857$

$b = 750.00$

" = 0.06082037

$y_{\text{comp}} = 1.5663730\text{E-}005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19957893 < t/d$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

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

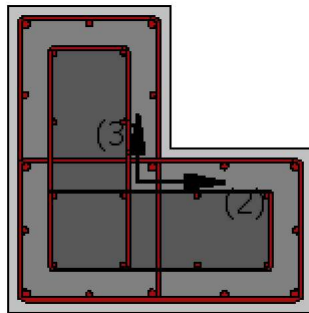
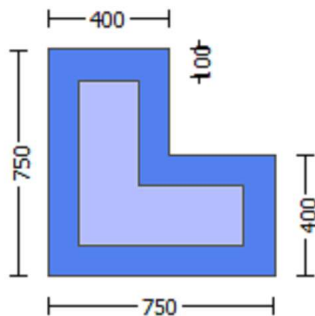
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

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

New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary 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 = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.0005439$

EDGE -B-

Shear Force,  $V_b = 0.0005439$

## BOTH EDGES

Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{c,com} = 2362.478$

-Middle:  $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$  with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.4307E+008$

$Mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.4307E+008$

$Mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

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

From (5.4b), TB DY:  $\phi_u = 0.00791261$

we (5.4c)  $= 0.01216945$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

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

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

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

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (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:  $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

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

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 \cdot esu1_{nominal}$  ((5.5), TBDY) = 0.032

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

For calculation of  $esu1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

with  $fs_1 = (f_{s,jacket} \cdot A_{sl,ten,jacket} + f_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 \cdot esu2_{nominal}$  ((5.5), TBDY) = 0.032

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

For calculation of  $esu2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

with  $fs_2 = (f_{s,jacket} \cdot A_{sl,com,jacket} + f_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 368.7326$

with  $Es_2 = (E_{s,jacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

```

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

```

and confined core properties:

```

b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

```

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

```

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

```

u = 9.3115772E-006
Mu = 8.4307E+008

```

with full section properties:

```

b = 400.00
d = 707.00
d' = 43.00
v = 0.00174912
N = 16323.501
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261
we (5.4c) = 0.01216945
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$$

```

with Es1 = (Esjacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.22227278
Mu = MRc (4.14) = 8.4307E+008
u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+

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

$$\phi_u = 8.5055191E-006$$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00791261$$

$$\phi_{we}(5.4c) = 0.01216945$$

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

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

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  $b_i d_i / 6$  as defined at (A.2).

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

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).

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

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2}((5.4d)) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket * Asl, \text{ten}, \text{jacket} + fs\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 367.9484$   
 with  $Es1 = (Es\_jacket * Asl, \text{ten}, \text{jacket} + Es\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs\_jacket * Asl, \text{com}, \text{jacket} + fs\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 368.7326$   
 with  $Es2 = (Es\_jacket * Asl, \text{com}, \text{jacket} + Es\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl, \text{mid}, \text{jacket} + fs\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 359.9093$   
 with  $Es_v = (Es\_jacket * Asl, \text{mid}, \text{jacket} + Es\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.02391392$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.04978341$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05078914$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.02714524$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.05651029$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

---

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

---->

$$s_u(4.9) = 0.14856848$$

$$\mu_u = M_{Rc}(4.14) = 5.0139E+008$$

$$u = s_u(4.1) = 8.5055191E-006$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2}$ -

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

$$u = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$$

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

$$\text{From (5.4b), TB DY: } \phi_u = 0.00791261$$

$$\phi_{ue}(5.4c) = 0.01216945$$

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

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

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)

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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)

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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).

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

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$\phi_{psh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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) = 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 = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 442.4791  
fy1 = 368.7326  
su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 368.7326

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

y2 = 0.00140044  
sh2 = 0.0044814

ft2 = 441.538  
fy2 = 367.9484

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9484

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

yv = 0.00140044  
shv = 0.0044814

ftv = 431.8911  
fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 359.9093

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

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483889$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, \text{TB DY}) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508886$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22227278$$

$$\mu_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$$V_{Col0} = 998297.143$$

$k_{nl} = 1$  (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:  $f'_c = (f'_c \cdot A_{jacket} + f'_c \cdot A_{core}) / A_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.4029$$

$$V_u = 0.0005439$$

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

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

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  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 998297.143$   
 $knl = 1$  (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)  
 $M/Vd = 4.00$   
 $\mu_u = 326.4024$   
 $V_u = 0.0005439$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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<sub>s,c2</sub> is multiplied by Col,c2 = 0.00  
s/d = 1.5625  
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: 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,  $\gamma$  = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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 = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping  
-----

Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -0.0005439$   
EDGE -B-  
Shear Force,  $V_b = 0.0005439$   
BOTH EDGES  
Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{c,com} = 2362.478$

-Middle:  $As_{c,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$  with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 8.4307E+008$

$\mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 8.4307E+008$

$\mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $\mu_{1+}$

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

$\phi_u = 8.5055191E-006$

$\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$\nu = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

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

From (5.4b), TBDY:  $\phi_u = 0.00791261$

we (5.4c) = 0.01216945

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

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

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).

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

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).

$psh_{min} \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh_{min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$

$psh1$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

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

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

$psh2$  ((5.4d)) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

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

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

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$

$psh1$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

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

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

$psh2$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

$L_{stir2}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lou_{min} = lb/ld = 0.30$

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

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

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

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

with  $fs1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 0.30$

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

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

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

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

with  $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 368.7326$

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

$yv = 0.00140044$

$shv = 0.0044814$

```

ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
    v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
    v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006
-----

Calculation of ratio lb/ld
-----
Inadequate Lap Length with lb/ld = 0.30
-----
-----
Calculation of Mu1-
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 9.3115772E-006
Mu = 8.4307E+008
-----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174912
N = 16323.501
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261
we (5.4c) = 0.01216945
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).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lo_{u,min} = l_b/l_d = 0.30$

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

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  $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 368.7326$

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

$y2 = 0.00140044$

```

sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 0.30
    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 = 367.9484
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.22227278
Mu = MRc (4.14) = 8.4307E+008
u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:  
u = 8.5055191E-006

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, \alpha) = 0.00791261$$

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

$$\text{From (5.4b), TB DY: } \mu = 0.00791261$$

$$\mu_e (5.4c) = 0.01216945$$

$$\alpha_e ((5.4d), \text{TB DY}) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.45746528$$

$$\alpha_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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).

$$\alpha_2 (> \alpha_1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

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

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$p_{sh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

$$\alpha_c = \text{confinement factor} = 1.00$$

```

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 0.30
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 0.30
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->

```



su (4.9) = 0.14856848  
Mu = MRc (4.14) = 5.0139E+008  
u = su (4.1) = 8.5055191E-006

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

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

u = 9.3115772E-006  
Mu = 8.4307E+008

with full section properties:

b = 400.00  
d = 707.00  
d' = 43.00  
v = 0.00174912  
N = 16323.501  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00791261

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

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

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.

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 bi2/6 as defined at (A.2).

ase2 (>=ase1) = 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 bi2/6 as defined at (A.2).

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 2.92621

Expression (5.4d) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

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

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 368.7326

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 367.9484

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

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 359.9093

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09334389

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.04483859$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22227278$$

$$M_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$$V_{Col0} = 998297.143$$

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

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

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

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

$$M/V_d = 4.00$$

$$M_u = 326.5735$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

where:

$$V_{s,jacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 279252.68$  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  $Col,j2 = 1.00$

$$s/d = 0.16666667$$

$$V_{s,core} = V_{sc1} + V_{sc2} = 78637.555$$

$V_{sc1} = 0.00$  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,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$   
 $V_{ColO} = 998297.143$   
 $knl = 1$  (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)  
 $M/Vd = 4.00$   
 $M_u = 326.5741$   
 $V_u = 0.0005439$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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  $Col,c2 = 1.00$   
 $s/d = 0.56818182$

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: 2  
Integration Section: (a)  
Section Type: rcjls

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -233750.983$   
Shear Force,  $V_2 = -7874.616$   
Shear Force,  $V_3 = 112.3724$   
Axial Force,  $F = -17081.857$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl} = 0.00$   
-Compression:  $A_{sc} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 2362.478$   
-Middle:  $A_{sl,mid} = 2469.292$   
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:  $A_{sl,com,core} = 615.7522$

-Middle:  $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = u = 0.00176802$

$u = y + p = 0.00176802$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00176802 ((4.29), \text{Biskinis Phd})$

$M_y = 3.6949E+008$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2080.146

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

factor = 0.30

$A_g = 440000.00$

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

$N = 17081.857$

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

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  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,  $t = 400.00$

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

$y_{ten} = 2.5827649E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with  $p_t = 0.00434791$

$p_c = 0.0044554$

$p_v = 0.00465684$

$N = 17081.857$

$b = 750.00$

" = 0.06082037

$y_{comp} = 1.5663730E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19957893 < t/d$

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00$

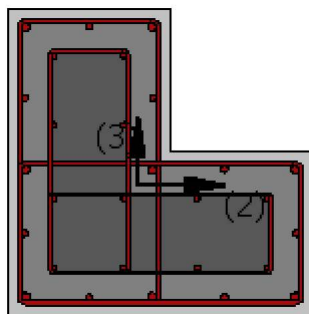
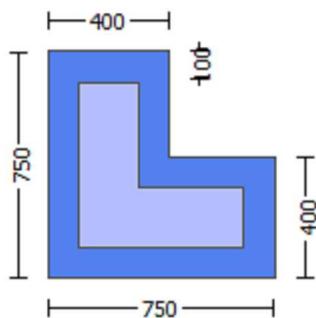
with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$   
shear control ratio  $V_{yE}/V_{ColOE} = 0.56300412$   
 $d = d_{external} = 707.00$   
 $s = s_{external} = 0.00$   
-  $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00434791$   
jacket:  $s_1 = A_{v1} \cdot L_{stir1}/(s_1 \cdot A_g) = 0.00367709$   
 $A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction  
 $L_{stir1} = 2060.00$ , 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  $2 \cdot t_f/bw \cdot (f_{fe}/f_s)$  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.  
 $NUD = 17081.857$   
 $A_g = 440000.00$   
 $f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core})/section\_area = 27.68182$   
 $f_{yE} = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf})/Area_{Tot\_Long\_Rein} = 521.1696$   
 $f_{yE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2)/(s_1 + s_2) = 538.4128$   
 $\rho_l = Area_{Tot\_Long\_Rein}/(b \cdot d) = 0.011257$   
 $b = 750.00$   
 $d = 707.00$   
 $f_{cE} = 27.68182$

-----  
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: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $VR_d$   
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: rcjls

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary 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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -233750.983$



Shear Force,  $V_a = 112.3724$   
 EDGE -B-  
 Bending Moment,  $M_b = -101183.60$   
 Shear Force,  $V_b = -112.3724$   
 BOTH EDGES  
 Axial Force,  $F = -17081.857$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{st} = 0.00$   
   -Compression:  $A_{sc} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{st,ten} = 1137.257$   
   -Compression:  $A_{sc,com} = 2362.478$   
   -Middle:  $A_{sc,mid} = 2469.292$   
 Mean Diameter of Tension Reinforcement,  $D_{bL,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 897900.016$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 897900.016$   
 $V_{CoI} = 897900.016$   
 $k_n = 1.00$   
 $displacement\_ductility\_demand = 0.02111012$

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).

$\phi = 1$  (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  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 3.46691$   
 $\mu_u = 233750.983$   
 $V_u = 112.3724$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 17081.857$   
 $A_g = 300000.00$   
 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  $\theta = 3.7323117E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00176802$  ((4.29), Biskinis Phd))  
 $M_y = 3.6949E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2080.146  
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:  $f'_c = (f'_{c\_jacket} * Area_{jacket} + f'_{c\_core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 17081.857$   
 $E_c * I_g = E_{c\_jacket} * I_{g\_jacket} + E_{c\_core} * I_{g\_core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $\phi < t/d$ , compression zone rectangular) with:  
flange width,  $b = 750.00$   
web width,  $bw = 400.00$   
flange thickness,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827649E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.20059112$   
 $A = 0.01136735$   
 $B = 0.00499612$   
with  $pt = 0.00214476$   
 $pc = 0.0044554$   
 $pv = 0.00465684$   
 $N = 17081.857$   
 $b = 750.00$   
 $\phi = 0.06082037$   
 $y_{comp} = 1.5663730E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866301$   
 $A = 0.01118379$   
 $B = 0.00488577$   
with  $E_s = 200000.00$   
CONFIRMATION:  $\phi = 0.19957893 < t/d$

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

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

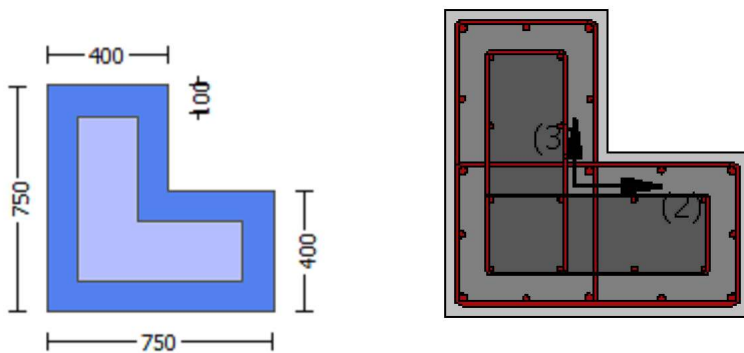
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{c,com} = 2362.478$   
   -Middle:  $As_{l,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$   
 $\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$   
 $\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $\mu_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5055191E-006$   
 $\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$

$co$  (5A.5, TBDY) = 0.002  
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we$  (5.4c) = 0.01216945  
 $ase$  ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$   
 $ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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  $bi^2/6$  as defined at (A.2).  
 $ase2 (>= ase1) = Max(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$   
 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  $bi^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((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

---

$A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.4444$   
 $fy_{we2} = 555.5556$   
 $f_{ce} = 33.00$   
 From ((5A5), TBDY), TBDY:  $cc = 0.002$   
 $c =$  confinement factor = 1.00  
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou_{min} = lb/d = 0.30$

$su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 367.9484$   
 with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$   
 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  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 368.7326$   
 with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 359.9093$   
 with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

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

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14856848$   
 $Mu = MRc (4.14) = 5.0139E+008$   
 $u = su (4.1) = 8.5055191E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

## Calculation of Mu1-

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

$$\mu = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu = \text{shear\_factor} * \text{Max}(\mu_c, \mu_o) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00791261$$

$$\mu_o (5.4c) = 0.01216945$$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

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

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

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

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

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

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

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

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

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

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

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

```

Asec = 440000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00
From ((5A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 442.4791
fy1 = 368.7326
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00

```



$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

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

--->

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

--->

$$s_u(4.9) = 0.22227278$$

$$\mu_u = M_{Rc}(4.14) = 8.4307E+008$$

$$u = s_u(4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{u2+}$

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

$$u = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.00791261$$

$$\mu_{we}(5.4c) = 0.01216945$$

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

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

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).

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

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).

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

Expression (5.4d) for  $\mu_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh\_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 \text{ (5.4d)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

$psh\_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along X)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along X)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

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

From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 367.9484$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$

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

$lo/lou, min = lb/lb, min = 0.30$

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

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

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

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

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 368.7326$

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

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.02391392$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04978341$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc$  (5A.2, TBDY) = 33.00  
 $cc$  (5A.5, TBDY) = 0.002  
 $c$  = confinement factor = 1.00  
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.02714524$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05651029$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05765191$

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

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

---->  
 $su$  (4.9) = 0.14856848  
 $Mu = MRc$  (4.14) = 5.0139E+008  
 $u = su$  (4.1) = 8.5055191E-006

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu2$ -

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

$u = 9.3115772E-006$   
 $Mu = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$

$fc = 33.00$   
 $co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00791261$

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

From (5.4b), TBDY:  $cu = 0.00791261$

we (5.4c) = 0.01216945

$ase$  ((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.

$Aconf,max1 = 353600.00$  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).  
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - \text{AnoConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

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).

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

Expression (5.4d) for  $psh,min * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.30$

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

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  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 441.538$

$fy2 = 367.9484$

$su2 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lo_{u,min} = lb/lb_{min} = 0.30$

$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,  
 For calculation of  $esu_{2\_nominal}$  and  $y_2$ ,  $sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$   
 with  $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.09334389$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04483859$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.09522963$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.11468265$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05508886$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fs_v / fc) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.22227278$

$\mu_u = MR_c (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$V_{Col0} = 998297.143$

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

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

$M/Vd = 4.00$   
 $\mu_u = 326.4029$   
 $\nu_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$   
 $V_{Col0} = 998297.143$   
 $knl = 1$  (zero step-static loading)

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

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

$M/Vd = 4.00$   
 $\mu_u = 326.4024$   
 $\nu_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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,  $= 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{c,com} = 2362.478$   
   -Middle:  $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$   
 $\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$   
 $\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $\mu_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5055191E-006$   
 $M_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $\phi_{co} (5A.5, TBDY) = 0.002$   
 Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \max(\phi_{cu}, \phi_{cc}) = 0.00791261$



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

From (5.4b), TBDY:  $c_u = 0.00791261$

$w_e$  (5.4c) = 0.01216945

$a_{se}$  ((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).

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

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).

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

Expression (5.4d) for  $p_{sh,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

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

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

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

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (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:  $c_c = 0.002$

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

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

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

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

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

For calculation of  $esu1\_nominal$  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  $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 367.9484$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$

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

$lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal \cdot ((5.5), TBDY) = 0.032$

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

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

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

with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 368.7326$

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

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal \cdot ((5.5), TBDY) = 0.032$

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

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

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

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

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.14856848$   
 $Mu = MRc (4.14) = 5.0139E+008$   
 $u = su (4.1) = 8.5055191E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

## Calculation of Mu1-

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

$$\mu = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00791261$$

$$\mu_{ue}(5.4c) = 0.01216945$$

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

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

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).

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$s_2 = 250.00$   
 $fy_{we1} = 694.4444$   
 $fy_{we2} = 555.5556$   
 $f_{ce} = 33.00$   
 From ((5A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 442.4791$   
 $fy_1 = 368.7326$   
 $su_1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 368.7326$   
 with  $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.538$   
 $fy_2 = 367.9484$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$   
 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.  
 with  $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 367.9484$   
 with  $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.09334389$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.04483859$   
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.09522963$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, \text{TBDY}) = 33.00$   
 $cc (5A.5, \text{TBDY}) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.11468265$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.05508886$

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $\mu_u(4.9) = 0.22227278$   
 $\mu_u = M_{Rc}(4.14) = 8.4307E+008$   
 $u = \mu_u(4.1) = 9.3115772E-006$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 8.5055191E-006$   
 $\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $\alpha(5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00791261$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.00791261$   
 $\mu_{ue}(5.4c) = 0.01216945$   
 $\mu_{ase}((5.4d), TBDY) = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.45746528$   
 $\mu_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
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).  
 $\mu_{ase2}(>= \mu_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$   
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).  
 $\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 2.92621$   
Expression (5.4d) for  $\mu_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\mu_{psh,x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.92621$

$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
 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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 367.9484

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 368.7326

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

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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  $fs_v = fsv/1.2$ , from table 5.1, TBDY.

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

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.02391392$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04978341$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 33.00

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

$c$  = confinement factor = 1.00

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.02714524$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05651029$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.14856848

$Mu = MRc$  (4.14) = 5.0139E+008

$u = su$  (4.1) = 8.5055191E-006

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu_2$ -

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

$u = 9.3115772E-006$

$Mu = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$fc = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00791261$

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

From (5.4b), TBDY:  $cu = 0.00791261$

$we$  (5.4c) = 0.01216945

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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  $bi^2/6$  as defined at (A.2).

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

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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c$  = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 431.8911$

$fy_v = 359.9093$

$suv = 0.00512$

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

$lo/lou_{min} = lb/ld = 0.30$

$suv = 0.4 \cdot es_{u\_nominal} ((5.5), TBDY) = 0.032$

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

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

For calculation of  $es_{u\_nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered characteristic value  $fs_v = fs_v/1.2$ , 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.

with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.09334389$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.04483859$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.09522963$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

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

$c = \text{confinement factor} = 1.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11468265$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05508886$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.22227278$

$Mu = MR_c (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

-----

Calculation of ratio  $lb/ld$

-----

Inadequate Lap Length with  $lb/ld = 0.30$

-----

-----

-----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$V_{Col0} = 998297.143$

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

-----

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

-----

$= 1$  (normal-weight concrete)

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

$M/Vd = 4.00$

$Mu = 326.5735$

$V_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$   
 $V_{ColO} = 998297.143$   
 $knl = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 326.5741$   
 $V_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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  $Col,j1 = 1.00$

$s/d = 0.3125$   
 $V_{s,j2} = 523598.776$  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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

-----  
 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: rcjls

Constant Properties

-----  
 Knowledge Factor,  $\gamma = 1.00$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -2.3735E+007$   
Shear Force,  $V2 = -7874.616$   
Shear Force,  $V3 = 112.3724$   
Axial Force,  $F = -17081.857$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_{lt} = 0.00$   
-Compression:  $As_{lc} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten} = 1137.257$   
-Compression:  $As_{l,com} = 2362.478$   
-Middle:  $As_{l,mid} = 2469.292$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten,jacket} = 829.3805$   
-Compression:  $As_{l,com,jacket} = 1746.726$   
-Middle:  $As_{l,mid,jacket} = 1545.664$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten,core} = 307.8761$   
-Compression:  $As_{l,com,core} = 615.7522$   
-Middle:  $As_{l,mid,core} = 923.6282$   
Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = u = 0.00256184$   
 $u = y + p = 0.00256184$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00256184$  ((4.29), Biskinis Phd))  
 $M_y = 3.6949E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3014.102  
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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 17081.857$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

#### Calculation of Yielding Moment $M_y$

Calculation of  $y$  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,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827649E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.20059112$   
 $A = 0.01136735$   
 $B = 0.00499612$   
with  $pt = 0.00434791$   
 $pc = 0.0044554$   
 $p_v = 0.00465684$

$N = 17081.857$   
 $b = 750.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.5663730E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866301$   
 $A = 0.01118379$   
 $B = 0.00488577$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $y = 0.19957893 < t/d$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00$

with:

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

shear control ratio  $V_y E / V_{col} E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

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

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

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

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

$s_1 = 100.00$

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

$A_{v2} = 50.26548$ , 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  $2 * t_f / b_w * (f_{fe} / f_s)$  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.

$N_{UD} = 17081.857$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section\_area = 27.68182$

$f_{yE} = (f_{y,ext\_Long\_Reinf} * Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} * Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 521.1696$

$f_{yE} = (f_{y,ext\_Trans\_Reinf} * s_1 + f_{y,int\_Trans\_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = Area_{Tot\_Long\_Rein} / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

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

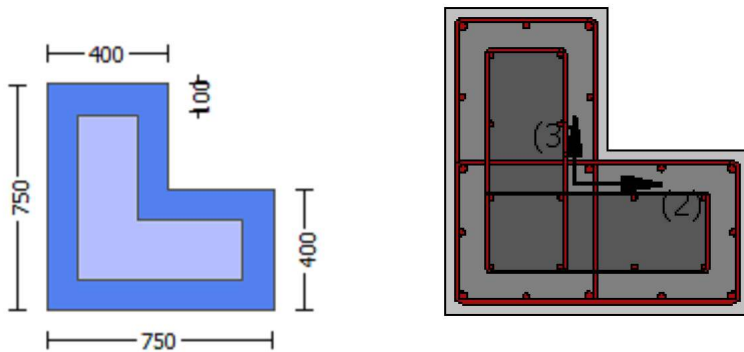
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcjls

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary 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  
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
 Bending Moment, Ma = -2.3735E+007  
 Shear Force, Va = -7874.616  
 EDGE -B-  
 Bending Moment, Mb = 105242.575  
 Shear Force, Vb = 7874.616  
 BOTH EDGES  
 Axial Force, F = -17081.857  
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension: Aslt = 0.00  
   -Compression: Aslc = 5969.026  
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension: Asl,ten = 1137.257  
   -Compression: Asl,com = 2362.478  
   -Middle: Asl,mid = 2469.292  
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR =  $V_n = 1.0166E+006$   
 $V_n ((10.3), ASCE 41-17) = knl * V_{Col0} = 1.0166E+006$   
 $V_{Col} = 1.0166E+006$   
 $knl = 1.00$   
 $displacement\_ductility\_demand = 0.09719975$

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)  
 $M/Vd = 2.00$   
 $M_u = 105242.575$   
 $V_u = 7874.616$   
 $d = 0.8 * h = 600.00$   
 $N_u = 17081.857$   
 $A_g = 300000.00$   
 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  $\delta / y$

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

From analysis, chord rotation  $\theta = 2.4784478E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00025498$  ((4.29), Biskinis Phd))  
 $M_y = 3.6949E+008$   
 $L_s = M/V$  (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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 17081.857$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta$  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,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827649E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.20059112$   
 $A = 0.01136735$   
 $B = 0.00499612$   
 with  $pt = 0.00214476$   
 $pc = 0.0044554$   
 $pv = 0.00465684$   
 $N = 17081.857$   
 $b = 750.00$   
 $\rho = 0.06082037$



$y_{comp} = 1.5663730E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866301$   
 $A = 0.01118379$   
 $B = 0.00488577$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $y = 0.19957893 < t/d$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

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

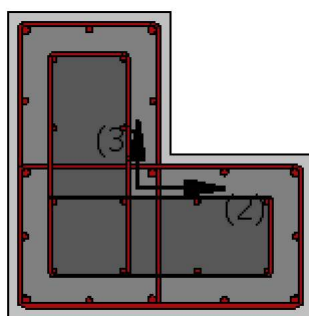
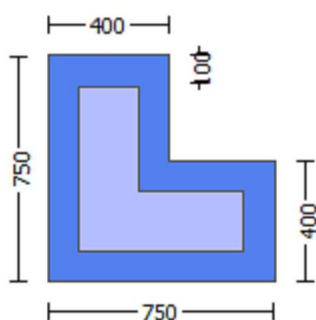
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

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: rcjics

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary 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 = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$

No FRP Wrapping

#### Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.0005439$

EDGE -B-

Shear Force,  $V_b = 0.0005439$

BOTH EDGES

Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{l,com} = 2362.478$

-Middle:  $As_{l,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$

$\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$

$\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction

which is defined for the the static loading combination

Mu2- = 8.4307E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$\nu = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00791261$$

$$\phi_{we} (5.4c) = 0.01216945$$

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

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

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).

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

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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 ((5A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

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

lo/lou,min = lb/lb = 0.30

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 = 367.9484

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 368.7326

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

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/lb = 0.30

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 = 359.9093

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.02391392

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04978341

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

```

fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006

```

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

Inadequate Lap Length with lb/l<sub>d</sub> = 0.30

Calculation of Mu1-

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

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00791261

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

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

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.

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) = 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).

$psh_{min} \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $psh_{min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1$  (Length of stirrups along Y) = 2060.00  
 $Astir1$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2$  (Length of stirrups along Y) = 1468.00  
 $Astir2$  (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1$  (Length of stirrups along X) = 2060.00  
 $Astir1$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2$  (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:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 442.4791$   
 $fy1 = 368.7326$   
 $su1 = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

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

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

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

with  $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 368.7326$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 441.538$   
 $fy2 = 367.9484$   
 $su2 = 0.00512$

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

$lo/lou, min = lb/lb, min = 0.30$

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

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

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

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

with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$

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

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

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

Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.09334389$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04483859$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.09522963$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.11468265$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05508886$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.11699947$

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

---->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 ---->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu2+$

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

$u = 8.5055191E-006$   
 $Mu = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$

$fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$

we (5.4c) = 0.01216945

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

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

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).  
 $psh_{min}*F_{ywe} = \text{Min}(psh_x*F_{ywe}, psh_y*F_{ywe}) = 2.92621$   
Expression (5.4d) for  $psh_{min}*F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without  
earthquake detailing (90° closed stirrups)

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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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 $A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.4444$   
 $fy_{we2} = 555.5556$   
 $f_{ce} = 33.00$   
From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $su1 = 0.4*es_{u1\_nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $es_{u1\_nominal} = 0.08$ ,  
For calculation of  $es_{u1\_nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fs_{y1} = fs1/1.2$ , 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  $fs1 = (f_{s,jacket}*A_{s1,ten,jacket} + f_{s,core}*A_{s1,ten,core})/A_{s1,ten} = 367.9484$   
with  $Es1 = (E_{s,jacket}*A_{s1,ten,jacket} + E_{s,core}*A_{s1,ten,core})/A_{s1,ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor



and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$   
 with  $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.02391392$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.04978341$   
 $v = A_{sl,mid} / (b * d) * (fs_v / fc) = 0.05078914$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.02714524$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.05651029$   
 $v = A_{sl,mid} / (b * d) * (fs_v / fc) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14856848$   
 $Mu = MR_c (4.14) = 5.0139E+008$   
 $u = su (4.1) = 8.5055191E-006$

-----  
 Calculation of ratio  $l_b/l_d$   
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Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----

-----  
 Calculation of  $Mu_2$ -  
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-----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

-----  
 with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we (5.4c) = 0.01216945$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$   
 $ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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).  
 $ase2 (>= ase1) = Max(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$   
 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).  
 $psh,min * F_{ywe} = Min(psh,x * F_{ywe}, psh,y * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $psh,min * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

$A_{sec} = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.4444$   
 $fywe2 = 555.5556$   
 $f_{ce} = 33.00$   
 From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c =$  confinement factor = 1.00  
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 442.4791$   
 $fy1 = 368.7326$   
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,  
 For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$   
 with  $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.538$   
 $fy_2 = 367.9484$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9484$   
 with  $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.09334389$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.04483859$   
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.09522963$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.11468265$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.05508886$   
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.11699947$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{ColO}$

$V_{ColO} = 998297.143$

$k_n l = 1$  (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:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.4029$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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  $Col,c2 = 0.00$

$s/d = 1.5625$

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

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

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{ColO}$

$V_{ColO} = 998297.143$

$k_n l = 1$  (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:  $f'_c = (f'_c \text{ jacket} \cdot \text{Area jacket} + f'_c \text{ core} \cdot \text{Area core}) / \text{Area section} = 27.68182$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M / Vd = 4.00$

$\mu_u = 326.4024$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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  $\text{Col,j1} = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  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  $\text{Col,j2} = 1.00$

$s/d = 0.3125$

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

$V_{s,c1} = 78637.555$  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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl,t} = 0.00$   
 -Compression:  $A_{sl,c} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl,ten} = 1137.257$   
 -Compression:  $A_{sl,com} = 2362.478$   
 -Middle:  $A_{sl,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$   
 $\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$   
 $\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $\mu_{u2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

Calculation of  $\mu_{1+}$

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

$$\mu = 8.5055191\text{E-}006$$

$$\mu_u = 5.0139\text{E+}008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u = \text{shear\_factor} * \text{Max}(\mu_u, \alpha) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00791261$$

$$\mu_{se} (5.4c) = 0.01216945$$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

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

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

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

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

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

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

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

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

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

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

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

```

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 = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 367.9484
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 368.7326
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002

```



$c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.02714524$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05651029$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su(4.9) = 0.14856848$   
 $Mu = MRc(4.14) = 5.0139E+008$   
 $u = su(4.1) = 8.5055191E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu1$ -

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

$u = 9.3115772E-006$   
 $Mu = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $co(5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00791261$

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

From (5.4b), TBDY:  $cu = 0.00791261$

we (5.4c) = 0.01216945

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

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

lo/lou,min = lb/lb = 0.30

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 = 368.7326

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 367.9484

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

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/lb = 0.30

$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 359.9093$   
 with  $Esv = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.09334389$   
 $2 = Asl\_com / (b * d) * (fs2 / fc) = 0.04483859$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.09522963$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.11468265$   
 $2 = Asl\_com / (b * d) * (fs2 / fc) = 0.05508886$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.11699947$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vsy2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Inadequate Lap Length with  $lb/ld = 0.30$   
 -----  
 -----  
 -----  
 Calculation of  $Mu2+$   
 -----  
 -----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 8.5055191E-006$   
 $Mu = 5.0139E+008$   
 -----  
 with full section properties:  
 $b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we (5.4c) = 0.01216945$   
 $ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.45746528$   
 $ase1 = \text{Max}(((Aconf\_max1 - AnoConf1) / Aconf\_max1) * (Aconf\_min1 / Aconf\_max1), 0) = 0.45746528$   
 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 ( $\geq$  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 =  $\text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

Expression (5.4d) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

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

lo/lou,min =  $l_b/l_d = 0.30$

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

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

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

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

with fs1 =  $(f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9484$

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 368.7326$   
 with  $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.02391392$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.04978341$   
 $v = Asl_{mid} / (b * d) * (fs_v / fc) = 0.05078914$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.02714524$   
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.05651029$   
 $v = Asl_{mid} / (b * d) * (fs_v / fc) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14856848$   
 $Mu = MRc (4.14) = 5.0139E+008$   
 $u = su (4.1) = 8.5055191E-006$

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Calculation of ratio  $l_b/l_d$

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Inadequate Lap Length with  $l_b/l_d = 0.30$

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Calculation of  $Mu_2$ -

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

$u = 9.3115772E-006$   
 $Mu = 8.4307E+008$

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with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$

$N = 16323.501$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha = 0.00791261$   
 $w_e (5.4c) = 0.01216945$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$   
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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).  
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$   
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

---

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$   
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along 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:  $\alpha_c = 0.002$   
 $\alpha_c = \text{confinement factor} = 1.00$   
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 442.4791$   
 $fy_1 = 368.7326$   
 $su_1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.22227278
Mu = MRc (4.14) = 8.4307E+008
u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/ld

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$V_{ColO} = 998297.143$

$k_n l = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 4.00$

$\mu_u = 326.5735$

$V_u = 0.0005439$

$d = 0.8 * h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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  $Col,c2 = 1.00$

$s/d = 0.56818182$

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

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

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$

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

$V_{ColO} = 998297.143$

$k_n l = 1$  (zero step-static loading)

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



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

= 1 (normal-weight concrete)

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

$M/Vd = 4.00$

$\mu_u = 326.5741$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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

New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_b/l_d = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -101183.60$   
 Shear Force,  $V_2 = 7874.616$   
 Shear Force,  $V_3 = -112.3724$   
 Axial Force,  $F = -17081.857$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{st} = 0.00$   
   -Compression:  $A_{sc} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{st,ten} = 1137.257$   
   -Compression:  $A_{sc,com} = 2362.478$   
   -Middle:  $A_{sc,mid} = 2469.292$   
 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:  $A_{sc,com,core} = 615.7522$   
   -Middle:  $A_{sc,mid,core} = 923.6282$   
 Mean Diameter of Tension Reinforcement,  $D_bL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{,R} = * u = 0.00076532$   
 $u = y + p = 0.00076532$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00076532$  ((4.29), Biskinis Phd))  
 $M_y = 3.6949E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 900.4311  
 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:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 17081.857$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

## Calculation of Yielding Moment $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

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

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

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

$y_{ten} = 2.5827649E-006$

with ((10.1), ASCE 41-17)  $f_y = \min(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with  $p_t = 0.00434791$

$p_c = 0.0044554$

$p_v = 0.00465684$

$N = 17081.857$

$b = 750.00$

" = 0.06082037

$y_{comp} = 1.5663730E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with  $E_s = 200000.00$

CONFIRMATION:  $\rho_y = 0.19957893 < t/d$

## Calculation of ratio $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

- Calculation of  $\rho_p$  -

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

with:

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

shear control ratio  $V_y E / V_{col} E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

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

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

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

$L_{stir1} = 2060.00$ , 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.

$N_{UD} = 17081.857$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section\_area = 27.68182$

$f_{yE} = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 521.1696$

$f_{yTE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$

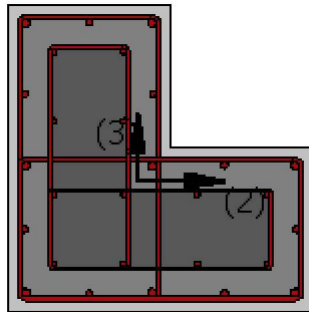
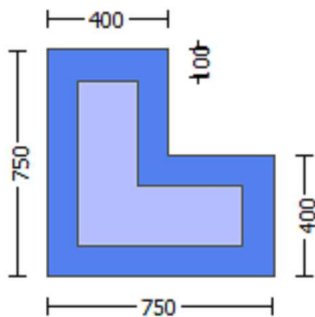
$\rho_l = Area_{Tot\_Long\_Rein} / (b \cdot d) = 0.011257$

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: 2  
Integration Section: (b)

## Calculation No. 7

column C1, Floor 1  
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity VR<sub>d</sub>  
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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -233750.983$   
Shear Force,  $V_a = 112.3724$   
EDGE -B-  
Bending Moment,  $M_b = -101183.60$   
Shear Force,  $V_b = -112.3724$   
BOTH EDGES  
Axial Force,  $F = -17081.857$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 2362.478$   
-Middle:  $A_{sl,mid} = 2469.292$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = *V_n = 1.0166E+006$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n l * V_{CoI} = 1.0166E+006$   
 $V_{CoI} = 1.0166E+006$   
 $k_n l = 1.00$   
displacement\_ductility\_demand =  $4.0853875E-005$

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)  
 $M/V_d = 2.00$   
 $M_u = 101183.60$   
 $V_u = 112.3724$

$d = 0.8 \cdot h = 600.00$   
 $Nu = 17081.857$   
 $Ag = 300000.00$   
 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  $\delta / y$

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

From analysis, chord rotation  $\theta = 3.1266345E-008$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00076532 ((4.29), Biskinis Phd)$   
 $M_y = 3.6949E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 900.4311  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.4491E+014$   
 $factor = 0.30$   
 $Ag = 440000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$   
 $N = 17081.857$   
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 4.8303E+014$

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,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

```

y = Min( y_ten, y_com)
y_ten = 2.5827649E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^ 2/3) = 291.9465
d = 707.00
y = 0.20059112
A = 0.01136735
B = 0.00499612
with pt = 0.00214476
pc = 0.0044554
pv = 0.00465684
N = 17081.857
b = 750.00
" = 0.06082037
y_comp = 1.5663730E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866301
A = 0.01118379
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19957893 < t/d

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

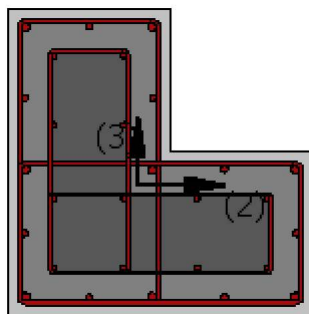
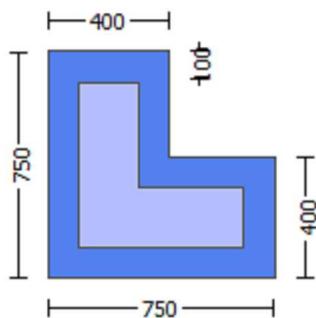
Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( u)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary 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 = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.0005439$

EDGE -B-

Shear Force,  $V_b = 0.0005439$



## BOTH EDGES

Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $As_{c,com} = 2362.478$

-Middle:  $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$  with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.4307E+008$

$Mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.4307E+008$

$Mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $Mu_{1+}$

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

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

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

From (5.4b), TDY:  $\phi_u = 0.00791261$

we (5.4c)  $= 0.01216945$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

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

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

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

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

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

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 \cdot esu1\_nominal$  ((5.5), TBDY) = 0.032

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

For calculation of  $esu1\_nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

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

with  $fs_1 = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 367.9484$

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

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

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

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 \cdot esu2\_nominal$  ((5.5), TBDY) = 0.032

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

For calculation of  $esu2\_nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

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

with  $fs_2 = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 368.7326$

with  $Es_2 = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$

```

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

```

and confined core properties:

```

b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

```

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

```

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

```

u = 9.3115772E-006
Mu = 8.4307E+008

```

with full section properties:

```

b = 400.00
d = 707.00
d' = 43.00
v = 0.00174912
N = 16323.501
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261
we (5.4c) = 0.01216945
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$L_{stir1}$  (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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY:  $c_c = 0.002$

$c$  = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$$

with  $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 441.538$   
 $fy2 = 367.9484$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{ou,min} = lb/lb_{min} = 0.30$   
 $su2 = 0.4 \cdot esu2_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,  
 For calculation of  $esu2_{nominal}$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$   
 with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{ou,min} = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.09334389$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.04483859$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.09522963$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.11468265$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05508886$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.11699947$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu2+$

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

$$\phi_u = 8.5055191E-006$$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.00791261$$

$$\phi_{we}(5.4c) = 0.01216945$$

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

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

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  $b_i d_i / 6$  as defined at (A.2).

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

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).

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

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket * Asl, \text{ten}, \text{jacket} + fs\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 367.9484$   
 with  $Es1 = (Es\_jacket * Asl, \text{ten}, \text{jacket} + Es\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs\_jacket * Asl, \text{com}, \text{jacket} + fs\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 368.7326$   
 with  $Es2 = (Es\_jacket * Asl, \text{com}, \text{jacket} + Es\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl, \text{mid}, \text{jacket} + fs\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 359.9093$   
 with  $Es_v = (Es\_jacket * Asl, \text{mid}, \text{jacket} + Es\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.02391392$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.04978341$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05078914$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.02714524$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.05651029$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

---

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

---->

$$s_u(4.9) = 0.14856848$$

$$M_u = M_{Rc}(4.14) = 5.0139E+008$$

$$u = s_u(4.1) = 8.5055191E-006$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $M_{u2}$ -

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

$$u = 9.3115772E-006$$

$$M_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e(5.4c) = 0.01216945$$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

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

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

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

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



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 = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 442.4791  
fy1 = 368.7326  
su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 368.7326

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

y2 = 0.00140044  
sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 367.9484

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

yv = 0.00140044  
shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 359.9093

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

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483889$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, \text{TBDY}) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508886$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22227278$$

$$\mu_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$$V_{Col0} = 998297.143$$

$k_{nl} = 1$  (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:  $f'_c = (f'_c \cdot A_{jacket} + f'_c \cdot A_{core}) / A_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.4029$$

$$V_u = 0.0005439$$

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

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

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  $Col,c2 = 0.00$   
 $s/d = 1.5625$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$   
 $V_{ColO} = 998297.143$   
 $knl = 1$  (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)  
 $M/Vd = 4.00$   
 $\mu_u = 326.4024$   
 $V_u = 0.0005439$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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<sub>s,c2</sub> is multiplied by Col,c2 = 0.00  
s/d = 1.5625  
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: 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,  $\gamma$  = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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 = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping  
-----

#### Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -0.0005439$   
EDGE -B-  
Shear Force,  $V_b = 0.0005439$   
BOTH EDGES  
Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

-Compression:  $A_{sc,com} = 2362.478$

-Middle:  $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.56300412$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$  with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 8.4307E+008$

$\mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 8.4307E+008$

$\mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $\mu_{1+}$

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

$\mu = 8.5055191E-006$

$\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

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

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \alpha) = 0.00791261$

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

From (5.4b), TBDY:  $\mu_u = 0.00791261$

we (5.4c) = 0.01216945

$\alpha_{se}$  ((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).

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh_{min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$

$psh1$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

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

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

$psh2$  (5.4d) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

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

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

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$

$psh1$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

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

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

$psh2$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

$L_{stir2}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lou_{min} = lb/ld = 0.30$

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

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

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

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

with  $fs1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 0.30$

$su2 = 0.4 \cdot esu2_{nominal}$  ((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  $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 368.7326$

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

$yv = 0.00140044$

$shv = 0.0044814$

```

ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
    v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
    v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006
-----

Calculation of ratio lb/ld
-----
Inadequate Lap Length with lb/ld = 0.30
-----
-----
Calculation of Mu1-
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 9.3115772E-006
Mu = 8.4307E+008
-----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174912
N = 16323.501
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261
we (5.4c) = 0.01216945
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).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (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

-----  
 $A_{sec} = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$f_{ywe1} = 694.4444$

$f_{ywe2} = 555.5556$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

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

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

Shear\_factor = 1.00

$lo/lo_{u,min} = l_b/l_d = 0.30$

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

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.

with  $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 368.7326$

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

$y2 = 0.00140044$



```

sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 0.30
    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 = 367.9484
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.22227278
Mu = MRc (4.14) = 8.4307E+008
u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+

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

u = 8.5055191E-006

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, \alpha) = 0.00791261$$

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

$$\text{From (5.4b), TB DY: } \mu = 0.00791261$$

$$\mu_e (5.4c) = 0.01216945$$

$$\alpha_e ((5.4d), \text{TB DY}) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.45746528$$

$$\alpha_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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).

$$\alpha_2 (> \alpha_1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

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

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

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

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$p_{sh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha = 0.002$$

$$\alpha = \text{confinement factor} = 1.00$$

```

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->

```

$s_u(4.9) = 0.14856848$   
 $\mu = MRC(4.14) = 5.0139E+008$   
 $u = s_u(4.1) = 8.5055191E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_2$ -

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

$u = 9.3115772E-006$   
 $\mu = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$

$f_c = 33.00$

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

Final value of  $\phi$ :  $\phi^* = \text{shear\_factor} * \text{Max}(\phi_c, \phi_s) = 0.00791261$

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

From (5.4b), TBDY:  $\phi_c = 0.00791261$

$\phi_s(5.4c) = 0.01216945$

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

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

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).

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

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).

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

Expression (5.4d) for  $\phi_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

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

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

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

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

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

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

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

$Asec = 440000.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.4444$

$fywe2 = 555.5556$

$fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

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

$lo/lou,min = lb/ld = 0.30$

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

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  $fs1 = (fs\_jacket * Asl,ten,jacket + fs\_core * Asl,ten,core) / Asl,ten = 368.7326$

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

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 441.538$

$fy2 = 367.9484$

$su2 = 0.00512$

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

$lo/lou,min = lb/lb,min = 0.30$

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

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  $fs2 = (fs\_jacket * Asl,com,jacket + fs\_core * Asl,com,core) / Asl,com = 367.9484$

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

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 431.8911$

$fyv = 359.9093$

$suv = 0.00512$

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

$lo/lou,min = lb/ld = 0.30$

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

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  $fsv = (fs\_jacket * Asl,mid,jacket + fs\_mid * Asl,mid,core) / Asl,mid = 359.9093$

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

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.09334389$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.04483859$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

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

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$$s_u (4.9) = 0.22227278$$

$$M_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$$V_{Col0} = 998297.143$$

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

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

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

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

$$M/V_d = 4.00$$

$$M_u = 326.5735$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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

where:

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

$V_{sj1} = 279252.68$  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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 998297.143$   
 $knl = 1$  (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)  
 $M/Vd = 4.00$   
 $M_u = 326.5741$   
 $V_u = 0.0005439$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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  $Col,c2 = 1.00$   
 $s/d = 0.56818182$

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: rcjls

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = 105242.575$   
Shear Force,  $V_2 = 7874.616$   
Shear Force,  $V_3 = -112.3724$   
Axial Force,  $F = -17081.857$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{sc,com} = 2362.478$   
-Middle:  $A_{sc,mid} = 2469.292$   
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:  $A_{sl,com,core} = 615.7522$

-Middle:  $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = u = 0.00025498$

$u = y + p = 0.00025498$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00025498 ((4.29), \text{Biskinis Phd})$

$M_y = 3.6949E+008$

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

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

factor = 0.30

$A_g = 440000.00$

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

$N = 17081.857$

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

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  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,  $t = 400.00$

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

$y_{ten} = 2.5827649E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.20059112$

$A = 0.01136735$

$B = 0.00499612$

with  $pt = 0.00434791$

$pc = 0.0044554$

$pv = 0.00465684$

$N = 17081.857$

$b = 750.00$

$" = 0.06082037$

$y_{comp} = 1.5663730E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866301$

$A = 0.01118379$

$B = 0.00488577$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19957893 < t/d$

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00$

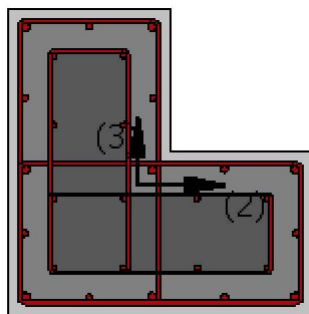
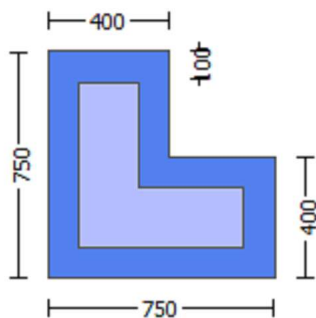
with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$   
shear control ratio  $V_{yE}/V_{ColOE} = 0.56300412$   
 $d = d_{external} = 707.00$   
 $s = s_{external} = 0.00$   
-  $t = s_1 + s_2 + 2*tf/bw*(f_{fe}/f_s) = 0.00434791$   
jacket:  $s_1 = A_{v1}*L_{stir1}/(s_1*Ag) = 0.00367709$   
 $A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction  
 $L_{stir1} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction  
 $s_1 = 100.00$   
core:  $s_2 = A_{v2}*L_{stir2}/(s_2*Ag) = 0.00067082$   
 $A_{v2} = 50.26548$ , 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  $2*tf/bw*(f_{fe}/f_s)$  is implemented to account for FRP contribution  
where  $f = 2*tf/bw$  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.  
 $NUD = 17081.857$   
 $Ag = 440000.00$   
 $f_{cE} = (f_{c\_jacket}*Area\_jacket + f_{c\_core}*Area\_core)/section\_area = 27.68182$   
 $f_{yE} = (f_{y\_ext\_Long\_Reinf}*Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf}*Area\_int\_Long\_Reinf)/Area\_Tot\_Long\_Rein = 521.1696$   
 $f_{yE} = (f_{y\_ext\_Trans\_Reinf}*s_1 + f_{y\_int\_Trans\_Reinf}*s_2)/(s_1 + s_2) = 538.4128$   
 $pl = Area\_Tot\_Long\_Rein/(b*d) = 0.011257$   
 $b = 750.00$   
 $d = 707.00$   
 $f_{cE} = 27.68182$

-----  
End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
-----

## Calculation No. 9

column C1, Floor 1  
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $VR_d$   
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: 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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary 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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -1.9722E+007$

Shear Force,  $V_a = -6543.324$   
 EDGE -B-  
 Bending Moment,  $M_b = 87505.349$   
 Shear Force,  $V_b = 6543.324$   
 BOTH EDGES  
 Axial Force,  $F = -16953.648$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{st} = 0.00$   
   -Compression:  $A_{sc} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{st,ten} = 1137.257$   
   -Compression:  $A_{sc,com} = 2362.478$   
   -Middle:  $A_{sc,mid} = 2469.292$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 876327.526$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \phi V_{CoI} = 876327.526$   
 $V_{CoI} = 876327.526$   
 $k_n = 1.00$   
 $displacement\_ductility\_demand = 0.03084783$

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).

$\phi = 1$  (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  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 1.9722E+007$   
 $V_u = 6543.324$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16953.648$   
 $A_g = 300000.00$   
 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  $\theta = 7.9019201E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00256158 ((4.29), Biskinis\ Phd)$   
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3014.111  
 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:  $f'_c = (f'_c\_jacket * Area\_jacket + f'_c\_core * Area\_core) / Area\_section = 27.68182$   
 $N = 16953.648$   
 $E_c * I_g = E_c\_jacket * I_g\_jacket + E_c\_core * I_g\_core = 4.8303E+014$

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,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827092E-006$   
 with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b / l_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.2005739$   
 $A = 0.01136652$   
 $B = 0.00499529$   
 with  $pt = 0.00214476$   
 $pc = 0.0044554$   
 $pv = 0.00465684$   
 $N = 16953.648$   
 $b = 750.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.5663957E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866014$   
 $A = 0.01118434$   
 $B = 0.00488577$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $y = 0.19956922 < t/d$

Calculation of ratio  $l_b / l_d$

Inadequate Lap Length with  $l_b / l_d = 0.30$

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

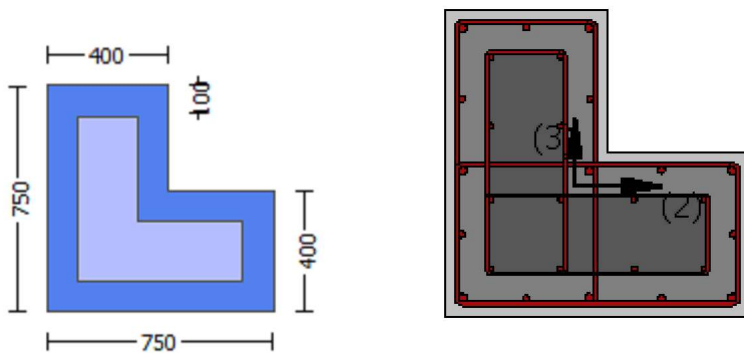
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

Edge: Start

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{c,com} = 2362.478$   
   -Middle:  $As_{l,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$   
 $\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$   
 $\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $\mu_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5055191E-006$   
 $M_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$

$co$  (5A.5, TBDY) = 0.002  
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we$  (5.4c) = 0.01216945  
 $ase$  ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$   
 $ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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  $bi^2/6$  as defined at (A.2).  
 $ase2 (>= ase1) = Max(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$   
 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  $bi^2/6$  as defined at (A.2).  
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

---

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((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 ((5A5), TBDY), TBDY:  $cc = 0.002$   
 $c$  = confinement factor = 1.00  
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00  
 $lo/lo_{min} = lb/d = 0.30$



$su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 367.9484$   
 with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 368.7326$   
 with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 359.9093$   
 with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.14856848$

$Mu = MRc (4.14) = 5.0139E+008$

$u = su (4.1) = 8.5055191E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

## Calculation of Mu1-

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

$$\mu = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu = \text{shear\_factor} * \text{Max}(\mu_c, cc) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.00791261$$

$$w_e \text{ (5.4c)} = 0.01216945$$

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

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

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).

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

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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

```

Asec = 440000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00
From ((5A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 442.4791
fy1 = 368.7326
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00

```

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

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

--->

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

--->

$$s_u(4.9) = 0.22227278$$

$$M_u = M_{Rc}(4.14) = 8.4307E+008$$

$$u = s_u(4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $M_{u2+}$

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

$$u = 8.5055191E-006$$

$$M_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \alpha: \alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \alpha = 0.00791261$$

$$\alpha_e(5.4c) = 0.01216945$$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh\_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 \text{ (5.4d)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

$psh\_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along X)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along X)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

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

From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

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

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

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

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 367.9484$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$

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

$lo/lou, min = lb/lb, min = 0.30$

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

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

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

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

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 368.7326$

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

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.02391392$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04978341$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc$  (5A.2, TBDY) = 33.00  
 $cc$  (5A.5, TBDY) = 0.002  
 $c$  = confinement factor = 1.00  
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.02714524$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05651029$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.05765191$

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

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

---->  
 $su$  (4.9) = 0.14856848  
 $Mu = MRc$  (4.14) = 5.0139E+008  
 $u = su$  (4.1) = 8.5055191E-006

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu2$ -

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

$u = 9.3115772E-006$   
 $Mu = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$

$fc = 33.00$   
 $co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00791261$

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

From (5.4b), TBDY:  $cu = 0.00791261$

we (5.4c) = 0.01216945

$ase$  ((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.

$Aconf,max1 = 353600.00$  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).  
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - \text{AnoConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

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).

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

Expression (5.4d) for  $psh,min * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh,x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
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  
-----

-----  
 $psh,y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$   
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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 368.7326

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,  
 For calculation of  $esu_{2\_nominal}$  and  $y_2$ ,  $sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$   
 with  $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.09334389$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.04483859$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.09522963$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11468265$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05508886$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.22227278$

$\mu_u = MR_c (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$V_{Col0} = 998297.143$

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

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



$M/Vd = 4.00$   
 $\mu_u = 326.4029$   
 $\nu_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$   
 $V_{Col0} = 998297.143$   
 $knl = 1$  (zero step-static loading)

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

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

$M/Vd = 4.00$   
 $\mu_u = 326.4024$   
 $\nu_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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,  $= 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{c,com} = 2362.478$   
   -Middle:  $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.4307E+008$   
 $Mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.4307E+008$   
 $Mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5055191E-006$   
 $M_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $\phi_o$  (5A.5, TBDY) = 0.002  
 Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_o) = 0.00791261$

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

From (5.4b), TBDY:  $c_u = 0.00791261$

$w_e$  (5.4c) = 0.01216945

$a_{se}$  ((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).

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

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).

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

Expression (5.4d) for  $p_{sh,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

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

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

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

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

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

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

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

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (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:  $c_c = 0.002$

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

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

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

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

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

For calculation of  $esu1\_nominal$  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  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 367.9484$

with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

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

$lo/lou, min = lb/lb, min = 0.30$

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

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

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

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

with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 368.7326$

with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$

$yv = 0.00140044$

$shv = 0.0044814$

$ftv = 431.8911$

$fyv = 359.9093$

$suv = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

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

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

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

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

with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 359.9093$

with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$

$1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$

$2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$

$v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 33.00$

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

$c = \text{confinement factor} = 1.00$

$1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$

$2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$

$v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.14856848$

$Mu = MRc (4.14) = 5.0139E+008$

$u = su (4.1) = 8.5055191E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

## Calculation of Mu1-

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

$$\mu = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_u = 0.00791261$$

$$\mu_{ue}(5.4c) = 0.01216945$$

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

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

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).

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

```

s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00
From ((5A.5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 442.4791
fy1 = 368.7326
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 0.30
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 0.30
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886

```

$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $\mu_u(4.9) = 0.22227278$   
 $\mu_u = M_{Rc}(4.14) = 8.4307E+008$   
 $u = \mu_u(4.1) = 9.3115772E-006$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2+}$

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

$\mu_u = 8.5055191E-006$   
 $\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$

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

Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, \mu_c) = 0.00791261$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.00791261$

$\mu_{ue}(5.4c) = 0.01216945$

$\mu_{ue}((5.4d), TBDY) = (\mu_{ue1} * A_{ext} + \mu_{ue2} * A_{int}) / A_{sec} = 0.45746528$

$\mu_{ue1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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).

$\mu_{ue2} (>= \mu_{ue1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

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).

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

Expression (5.4d) for  $\mu_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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



$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
 $Lstir1$  (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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 367.9484

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 368.7326

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

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/ld = 0.30

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  $fs_v = fsv/1.2$ , from table 5.1, TBDY.

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

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

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

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.02391392$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04978341$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 33.00

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

$c$  = confinement factor = 1.00

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.02714524$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05651029$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su$  (4.9) = 0.14856848

$Mu = MRc$  (4.14) = 5.0139E+008

$u = su$  (4.1) = 8.5055191E-006

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu_2$ -

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

$u = 9.3115772E-006$

$Mu = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$fc = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00791261$

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

From (5.4b), TBDY:  $cu = 0.00791261$

$we$  (5.4c) = 0.01216945

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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  $bi^2/6$  as defined at (A.2).

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

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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

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

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

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

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

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

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c$  = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

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

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.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$$

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

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

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

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

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

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  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$

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

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 431.8911$

$fy_v = 359.9093$

$suv = 0.00512$

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

$lo/lo_{u,min} = lb/ld = 0.30$

$suv = 0.4 \cdot es_{u\_nominal} ((5.5), TBDY) = 0.032$

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

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

For calculation of  $es_{u\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $fs_v = fs_v/1.2$ , 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.

with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.09334389$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.04483859$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.09522963$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

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

$c = \text{confinement factor} = 1.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11468265$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05508886$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

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

--->

$su (4.9) = 0.22227278$

$Mu = MR_c (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

-----

Calculation of ratio  $lb/ld$

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Inadequate Lap Length with  $lb/ld = 0.30$

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Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

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

$V_{Col0} = 998297.143$

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

-----

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

-----

$= 1$  (normal-weight concrete)

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

$M/Vd = 4.00$

$Mu = 326.5735$

$V_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$   
 $V_{ColO} = 998297.143$   
 $knl = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 326.5741$   
 $V_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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  $Col,j1 = 1.00$

$s/d = 0.3125$   
 $V_{s,j2} = 523598.776$  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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

-----  
 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: rcjls

Constant Properties

-----  
 Knowledge Factor,  $\phi = 1.00$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -194177.576$   
Shear Force,  $V_2 = -6543.324$   
Shear Force,  $V_3 = 93.37449$   
Axial Force,  $F = -16953.648$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{c,com} = 2362.478$   
-Middle:  $As_{c,mid} = 2469.292$   
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:  $As_{c,com,core} = 615.7522$   
-Middle:  $As_{c,mid,core} = 923.6282$   
Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_R = \phi_u = 0.04073976$   
 $\phi_u = \phi_y + \phi_p = 0.04073976$

- Calculation of  $\phi_y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00176734$  ((4.29), Biskinis Phd))  
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2079.557  
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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16953.648$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

#### 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,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827092E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.2005739$   
 $A = 0.01136652$   
 $B = 0.00499529$   
with  $pt = 0.00434791$   
 $pc = 0.0044554$   
 $p_v = 0.00465684$

$N = 16953.648$   
 $b = 750.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.5663957E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866014$   
 $A = 0.01118434$   
 $B = 0.00488577$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $y = 0.19956922 < t/d$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03897242$

with:

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

shear control ratio  $V_y E / V_{col} E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

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

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

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

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

$s_1 = 100.00$

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

$A_{v2} = 50.26548$ , 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  $2 * t_f / b_w * (f_{fe} / f_s)$  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.

$N_{UD} = 16953.648$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section\_area = 27.68182$

$f_{yE} = (f_{y,ext\_Long\_Reinf} * Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} * Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 521.1696$

$f_{yE} = (f_{y,ext\_Trans\_Reinf} * s_1 + f_{y,int\_Trans\_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = Area_{Tot\_Long\_Rein} / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

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

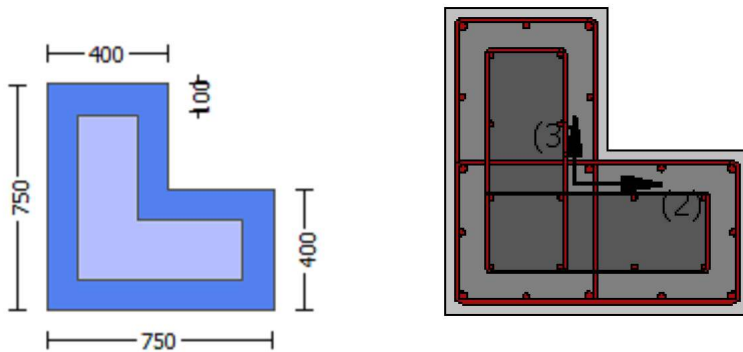
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

Existing material of Secondary 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  
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = l_b/l_d = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
 Bending Moment, Ma = -194177.576  
 Shear Force, Va = 93.37449  
 EDGE -B-  
 Bending Moment, Mb = -84132.56  
 Shear Force, Vb = -93.37449  
 BOTH EDGES  
 Axial Force, F = -16953.648  
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension: Aslt = 0.00  
   -Compression: Aslc = 5969.026  
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension: Asl,ten = 1137.257  
   -Compression: Asl,com = 2362.478  
   -Middle: Asl,mid = 2469.292  
 Mean Diameter of Tension Reinforcement, DbL,ten = 16.80

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR =  $V_n = 897931.212$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 897931.212$   
 $V_{CoI} = 897931.212$   
 $k_n = 1.00$   
 displacement\_ductility\_demand = 0.0175448

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)  
 $M/Vd = 3.46593$   
 $M_u = 194177.576$   
 $V_u = 93.37449$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16953.648$   
 $A_g = 300000.00$   
 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  $\delta_u / y$

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

From analysis, chord rotation  $\theta_r = 3.1007595E-005$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00176734 ((4.29), Biskinis Phd)$   
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 2079.557  
 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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16953.648$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

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

Assuming neutral axis within flange ( $y_c < t/d$ , compression zone rectangular) with:  
 flange width,  $b = 750.00$   
 web width,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827092E-006$   
 with  $((10.1), ASCE 41-17)$   $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b/d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.2005739$   
 $A = 0.01136652$   
 $B = 0.00499529$   
 with  $pt = 0.00214476$   
 $pc = 0.0044554$   
 $pv = 0.00465684$   
 $N = 16953.648$   
 $b = 750.00$   
 $\rho = 0.06082037$

y\_comp = 1.5663957E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.19866014  
A = 0.01118434  
B = 0.00488577  
with Es = 200000.00  
CONFIRMATION: y = 0.19956922 < t/d

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

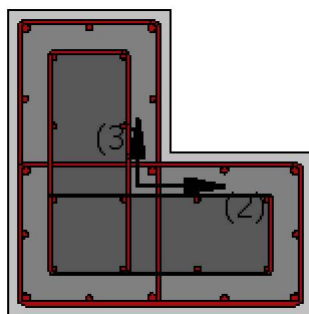
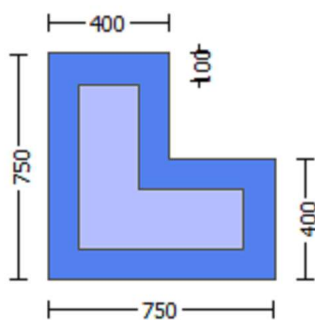
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( u)

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, = 1.00

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

```

Consequently:
Jacket
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$ 
Existing material of Secondary 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 = 1.00
Element Length,  $L = 3000.00$ 
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$ 
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -0.0005439$ 
EDGE -B-
Shear Force,  $V_b = 0.0005439$ 
BOTH EDGES
Axial Force,  $F = -16323.501$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{sl,t} = 0.00$ 
-Compression:  $A_{sl,c} = 5969.026$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl,ten} = 1137.257$ 
-Compression:  $A_{sl,com} = 2362.478$ 
-Middle:  $A_{sl,mid} = 2469.292$ 
-----
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$ 
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.4307E+008$ 
 $Mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $Mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.4307E+008$ 
 $Mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction

```

which is defined for the the static loading combination

Mu2- = 8.4307E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$\nu = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{co}) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.00791261$$

$$\phi_{we} (5.4c) = 0.01216945$$

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

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

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).

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

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).

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

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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

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

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

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

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

$$\phi_{psh2} ((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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 ((5A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

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

lo/lou,min = lb/lb = 0.30

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 = 367.9484

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 368.7326

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

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

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

lo/lou,min = lb/lb = 0.30

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 = 359.9093

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.02391392

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.04978341

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.05078914

and confined core properties:

b = 690.00

d = 677.00

d' = 13.00

```

fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

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

u = 9.3115772E-006

Mu = 8.4307E+008

with full section properties:

b = 400.00

d = 707.00

d' = 43.00

v = 0.00174912

N = 16323.501

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.00791261

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

From (5.4b), TBDY: cu = 0.00791261

we (5.4c) = 0.01216945

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.

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 bi2/6 as defined at (A.2).

ase2 (>=ase1) = 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 bi2/6 as defined at (A.2).



$psh_{min} \cdot F_{ywe} = \min(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $psh_{min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1$  (Length of stirrups along Y) = 2060.00  
 $Astir1$  (stirrups area) = 78.53982  
 $psh2$  (5.4d) =  $Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2$  (Length of stirrups along Y) = 1468.00  
 $Astir2$  (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1$  ((5.4d), TBDY) =  $Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1$  (Length of stirrups along X) = 2060.00  
 $Astir1$  (stirrups area) = 78.53982  
 $psh2$  ((5.4d), TBDY) =  $Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2$  (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:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 442.4791$   
 $fy1 = 368.7326$   
 $su1 = 0.00512$

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

$lo/lou, min = lb/ld = 0.30$

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

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

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

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

with  $fs1 = (fs_{jacket} \cdot Asl, ten, jacket + fs_{core} \cdot Asl, ten, core) / Asl, ten = 368.7326$

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

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 441.538$   
 $fy2 = 367.9484$   
 $su2 = 0.00512$

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

$lo/lou, min = lb/lb, min = 0.30$

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

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

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

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

with  $fs2 = (fs_{jacket} \cdot Asl, com, jacket + fs_{core} \cdot Asl, com, core) / Asl, com = 367.9484$

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

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

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

Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.09334389$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.04483859$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.09522963$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.11468265$   
 $2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.05508886$   
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.11699947$

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

---->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 ---->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu2+$

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

$u = 8.5055191E-006$   
 $Mu = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we (5.4c) = 0.01216945$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$   
 $ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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).  
 $psh_{min}*F_{ywe} = \text{Min}(psh_x*F_{ywe}, psh_y*F_{ywe}) = 2.92621$   
Expression (5.4d) for  $psh_{min}*F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without  
earthquake detailing (90° closed stirrups)

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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  
-----

-----  
 $psh_y*F_{ywe} = psh1*F_{ywe1} + ps2*F_{ywe2} = 2.92621$   
 $psh1 ((5.4d), TBDY) = L_{stir1}*A_{stir1}/(A_{sec}*s1) = 0.00367709$   
 $L_{stir1}$  (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:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $su1 = 0.4*es_{u1\_nominal} ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $es_{u1\_nominal} = 0.08$ ,  
For calculation of  $es_{u1\_nominal}$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fs_{y1} = fs1/1.2$ , 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  $fs1 = (f_{s,jacket}*A_{sl,ten,jacket} + f_{s,core}*A_{sl,ten,core})/A_{sl,ten} = 367.9484$   
with  $Es1 = (E_{s,jacket}*A_{sl,ten,jacket} + E_{s,core}*A_{sl,ten,core})/A_{sl,ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 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  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 368.7326$   
 with  $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.02391392$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.04978341$   
 $v = A_{sl,mid} / (b * d) * (fs_v / f_c) = 0.05078914$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / f_c) = 0.02714524$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / f_c) = 0.05651029$   
 $v = A_{sl,mid} / (b * d) * (fs_v / f_c) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.14856848$   
 $Mu = MR_c (4.14) = 5.0139E+008$   
 $u = su (4.1) = 8.5055191E-006$

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

Inadequate Lap Length with  $l_b/l_d = 0.30$   
 -----  
 -----  
 -----

Calculation of  $Mu_2$ -  
 -----  
 -----  
 -----

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

$$u = 9.3115772E-006$$

$$Mu = 8.4307E+008$$

-----  
 with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha = 0.00791261$   
 $\alpha_{se} (5.4c) = 0.01216945$   
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.45746528$   
 $\alpha_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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).  
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$   
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$   
 $L_{stir1}$  (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 ((5A.5), TBDY), TBDY:  $\alpha_c = 0.002$   
 $\alpha_c$  = confinement factor = 1.00  
 $y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 442.4791$   
 $fy_1 = 368.7326$   
 $su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{1,nominal} = 0.08$ ,  
 For calculation of  $esu_{1,nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$   
 with  $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$   
 $y_2 = 0.00140044$   
 $sh_2 = 0.0044814$   
 $ft_2 = 441.538$   
 $fy_2 = 367.9484$   
 $su_2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 367.9484$   
 with  $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 0.30$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.09334389$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.04483859$   
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.09522963$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.11468265$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.05508886$   
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.11699947$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{Col0}$

$V_{Col0} = 998297.143$

$k_n l = 1$  (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)

$M/Vd = 4.00$

$\mu_u = 326.4029$

$V_u = 0.0005439$

$d = 0.8 * h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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  $Col,c2 = 0.00$

$s/d = 1.5625$

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

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

$b_w = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_n l^* V_{Col0}$

$V_{Col0} = 998297.143$

$k_n l = 1$  (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:  $f'_c = (f'_c \text{ jacket} \cdot \text{Area jacket} + f'_c \text{ core} \cdot \text{Area core}) / \text{Area section} = 27.68182$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.4024$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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  $\text{Col,j1} = 1.00$

$s/d = 0.16666667$

$V_{s,j2} = 279252.68$  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  $\text{Col,j2} = 1.00$

$s/d = 0.3125$

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

$V_{s,c1} = 78637.555$  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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{sl,t} = 0.00$   
 -Compression:  $A_{sl,c} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{sl,ten} = 1137.257$   
 -Compression:  $A_{sl,com} = 2362.478$   
 -Middle:  $A_{sl,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$   
 $\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$   
 $\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $\mu_{u2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment

direction which is defined for the the static loading combination

Calculation of  $\mu_{1+}$

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

$$\mu = 8.5055191\text{E-}006$$

$$\mu_{1+} = 5.0139\text{E+}008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{1+}: \mu_{1+} = \text{shear\_factor} * \text{Max}(\mu_{1+}, \alpha) = 0.00791261$$

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

$$\text{From (5.4b), TBDY: } \mu_{1+} = 0.00791261$$

$$\mu_{1+} (5.4c) = 0.01216945$$

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

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

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).

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

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

```

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 = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 367.9484
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 368.7326
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002

```

$c = \text{confinement factor} = 1.00$   
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.02714524$   
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05651029$   
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is satisfied  
 --->  
 $su(4.9) = 0.14856848$   
 $Mu = MRc(4.14) = 5.0139E+008$   
 $u = su(4.1) = 8.5055191E-006$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $Mu1$ -

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

$u = 9.3115772E-006$   
 $Mu = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$   
 $f_c = 33.00$

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

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00791261$

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

From (5.4b), TBDY:  $cu = 0.00791261$

$we(5.4c) = 0.01216945$

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

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

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).

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

Expression (5.4d) for  $psh,min * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without

earthquake detailing (90° closed stirrups)

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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

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

lo/lou,min = lb/ld = 0.30

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 = 368.7326

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

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

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

lo/lou,min = lb/lb,min = 0.30

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 = 367.9484

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

$suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 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  $fsv = (fs\_jacket * Asl\_mid\_jacket + fs\_mid * Asl\_mid\_core) / Asl\_mid = 359.9093$   
 with  $Esv = (Es\_jacket * Asl\_mid\_jacket + Es\_mid * Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.09334389$   
 $2 = Asl\_com / (b * d) * (fs2 / fc) = 0.04483859$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.09522963$   
 and confined core properties:  
 $b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl\_ten / (b * d) * (fs1 / fc) = 0.11468265$   
 $2 = Asl\_com / (b * d) * (fs2 / fc) = 0.05508886$   
 $v = Asl\_mid / (b * d) * (fsv / fc) = 0.11699947$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < vsy2$  - LHS eq.(4.5) is satisfied  
 --->  
 $su (4.9) = 0.22227278$   
 $Mu = MRc (4.14) = 8.4307E+008$   
 $u = su (4.1) = 9.3115772E-006$   
 -----  
 Calculation of ratio  $lb/ld$   
 -----  
 Inadequate Lap Length with  $lb/ld = 0.30$   
 -----  
 -----  
 -----  
 Calculation of  $Mu2+$   
 -----  
 -----  
 Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 8.5055191E-006$   
 $Mu = 5.0139E+008$   
 -----  
 with full section properties:  
 $b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we (5.4c) = 0.01216945$   
 $ase ((5.4d), TBDY) = (ase1 * Aext + ase2 * Aint) / Asec = 0.45746528$   
 $ase1 = \text{Max}(((Aconf\_max1 - AnoConf1) / Aconf\_max1) * (Aconf\_min1 / Aconf\_max1), 0) = 0.45746528$   
 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 ( $\geq$  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 =  $\text{Min}(psh_x * Fywe, psh_y * Fywe) = 2.92621$

Expression (5.4d) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

lo/lou,min =  $l_b/l_d = 0.30$

su1 =  $0.4 * esu1_{\text{nominal}} ((5.5), \text{TBDY}) = 0.032$

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1, ft1, fy1, it is considered characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by  $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 =  $(f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 367.9484$

with Es1 =  $(E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

```

lo/lou,min = lb/lbmin = 0.30
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 = (fsjacket*Aslcom,jacket + fscore*Aslcom,core)/Aslcom = 368.7326
with Es2 = (Esjacket*Aslcom,jacket + Escore*Aslcom,core)/Aslcom = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
suv = 0.4*esuvnominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuvnominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuvnominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)2/3), from 10.3.5, ASCE 41-17.
with fsv = (fsjacket*Aslmid,jacket + fsmid*Aslmid,core)/Aslmid = 359.9093
with Esv = (Esjacket*Aslmid,jacket + Esmid*Aslmid,core)/Aslmid = 200000.00
1 = Aslten/(b*d)*(fs1/fc) = 0.02391392
2 = Aslcom/(b*d)*(fs2/fc) = 0.04978341
v = Aslmid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Aslten/(b*d)*(fs1/fc) = 0.02714524
2 = Aslcom/(b*d)*(fs2/fc) = 0.05651029
v = Aslmid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006

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Calculation of ratio lb/l<sub>d</sub>

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Inadequate Lap Length with lb/l<sub>d</sub> = 0.30

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Calculation of Mu<sub>2</sub>-

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Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 9.3115772E-006  
Mu = 8.4307E+008

-----

with full section properties:

b = 400.00  
d = 707.00  
d' = 43.00  
v = 0.00174912



$N = 16323.501$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
 Final value of  $\alpha$ :  $\alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\alpha = 0.00791261$   
 $w_e (5.4c) = 0.01216945$   
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$   
 $a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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).  
 $p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$   
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along Y) = 2060.00  
 $A_{stir1}$  (stirrups area) = 78.53982  
 $p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$   
 $L_{stir2}$  (Length of stirrups along Y) = 1468.00  
 $A_{stir2}$  (stirrups area) = 50.26548

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$   
 $p_{sh1} ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$   
 $L_{stir1}$  (Length of stirrups along 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:  $\alpha_c = 0.002$   
 $\alpha_c$  = confinement factor = 1.00

$y_1 = 0.00140044$   
 $sh_1 = 0.0044814$   
 $ft_1 = 442.4791$   
 $fy_1 = 368.7326$   
 $su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.22227278
Mu = MRc (4.14) = 8.4307E+008
u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/ld

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$V_{r1} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_n l V_{\text{ColO}}$

$V_{\text{ColO}} = 998297.143$

$k_n l = 1$  (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:  $f'_c = (f'_{c, \text{jacket}} \cdot \text{Area}_{\text{jacket}} + f'_{c, \text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 27.68182$ , but  $f'_c^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 326.5735$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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,  $V_{r2} = 998297.143$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_n l V_{\text{ColO}}$

$V_{\text{ColO}} = 998297.143$

$k_n l = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ '

where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$\mu_u = 326.5741$

$V_u = 0.0005439$

$d = 0.8 \cdot h = 600.00$

$N_u = 16323.501$

$A_g = 300000.00$

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), 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: (a)

Section Type: rcjls

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -1.9722E+007$   
Shear Force,  $V_2 = -6543.324$   
Shear Force,  $V_3 = 93.37449$   
Axial Force,  $F = -16953.648$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 2362.478$   
-Middle:  $A_{sl,mid} = 2469.292$   
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:  $A_{sl,com,core} = 615.7522$   
-Middle:  $A_{sl,mid,core} = 923.6282$   
Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_{R} = u = 0.041534$   
 $u = y + p = 0.041534$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00256158 ((4.29), \text{Biskinis Phd})$   
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3014.111  
From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 1.4491E+014$   
factor = 0.30  
 $A_g = 440000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182$   
 $N = 16953.648$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 4.8303E+014$

## Calculation of Yielding Moment $M_y$

Calculation of  $\rho_y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $\rho_y < t/d$ , compression zone rectangular) with:

flange width,  $b = 750.00$

web width,  $b_w = 400.00$

flange thickness,  $t = 400.00$

$y = \min(y_{ten}, y_{com})$

$y_{ten} = 2.5827092E-006$

with ((10.1), ASCE 41-17)  $f_y = \min(f_y, 1.25 \cdot f_y \cdot (l_b/d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.2005739$

$A = 0.01136652$

$B = 0.00499529$

with  $p_t = 0.00434791$

$p_c = 0.0044554$

$p_v = 0.00465684$

$N = 16953.648$

$b = 750.00$

$\rho_y = 0.06082037$

$y_{comp} = 1.5663957E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866014$

$A = 0.01118434$

$B = 0.00488577$

with  $E_s = 200000.00$

CONFIRMATION:  $\rho_y = 0.19956922 < t/d$

## Calculation of ratio $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

- Calculation of  $\rho_p$  -

From table 10-8:  $\rho_p = 0.03897242$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/d < 1$

shear control ratio  $V_y E / V_{col} E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

-  $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00434791$

jacket:  $s_1 = A_{v1} \cdot L_{stir1} / (s_1 \cdot A_g) = 0.00367709$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2060.00$ , 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.

$N_{UD} = 16953.648$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section\_area = 27.68182$

$f_{yE} = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 521.1696$

$f_{yE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 538.4128$

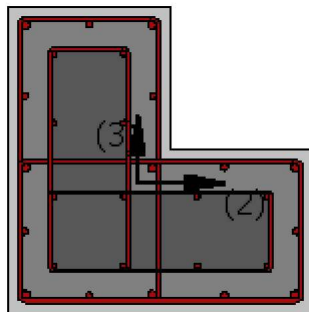
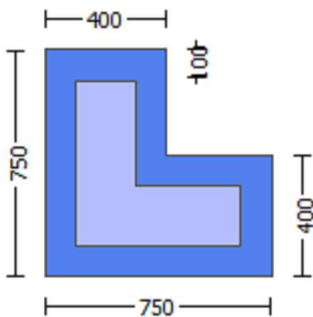
$\rho_l = Area_{Tot\_Long\_Rein} / (b \cdot d) = 0.011257$

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: (a)

## Calculation No. 13

column C1, Floor 1  
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity VR<sub>d</sub>  
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: 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 Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -1.9722E+007$   
Shear Force,  $V_a = -6543.324$   
EDGE -B-  
Bending Moment,  $M_b = 87505.349$   
Shear Force,  $V_b = 6543.324$   
BOTH EDGES  
Axial Force,  $F = -16953.648$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 1137.257$   
-Compression:  $A_{sl,com} = 2362.478$   
-Middle:  $A_{sl,mid} = 2469.292$   
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) =  $k_n l V_{CoI} = 1.0165E+006$   
 $V_{CoI} = 1.0165E+006$   
 $k_n l = 1.00$   
displacement\_ductility\_demand = 0.08075324

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:  $f'_c = (f'_{c\_jacket} \cdot Area\_jacket + f'_{c\_core} \cdot Area\_core) / Area\_section = 21.31818$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/V_d = 2.00$   
 $M_u = 87505.349$   
 $V_u = 6543.324$



$d = 0.8 \cdot h = 600.00$   
 $Nu = 16953.648$   
 $Ag = 300000.00$   
 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:  
 $d = 320.00$   
 $Av = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j1}$  is multiplied by  $Col,j1 = 1.00$   
 $s/d = 0.3125$   
 $V_{s,j2} = 471238.898$  is calculated for section flange jacket, with:  
 $d = 600.00$   
 $Av = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s,j2}$  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:  
 $d = 160.00$   
 $Av = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c1}$  is multiplied by  $Col,c1 = 0.00$   
 $s/d = 1.5625$   
 $V_{s,c2} = 70773.799$  is calculated for section flange core, with:  
 $d = 440.00$   
 $Av = 100530.965$   
 $f_y = 400.00$   
 $s = 250.00$   
 $V_{s,c2}$  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  $\delta / y$

- Calculation of  $\delta / y$  for END B -  
for rotation axis 3 and integ. section (b)

From analysis, chord rotation  $\theta = 2.0588749E-005$   
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.00025496 ((4.29), Biskinis Phd)$   
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) =  $300.00$   
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.4491E+014$   
 $factor = 0.30$   
 $Ag = 440000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$   
 $N = 16953.648$   
 $E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 4.8303E+014$

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,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

```

y = Min( y_ten, y_com)
y_ten = 2.5827092E-006
with ((10.1), ASCE 41-17) fy = Min(fy, 1.25*fy*(lb/ld)^ 2/3) = 291.9465
d = 707.00
y = 0.2005739
A = 0.01136652
B = 0.00499529
with pt = 0.00214476
pc = 0.0044554
pv = 0.00465684
N = 16953.648
b = 750.00
" = 0.06082037
y_comp = 1.5663957E-005
with fc = 33.00
Ec = 26999.444
y = 0.19866014
A = 0.01118434
B = 0.00488577
with Es = 200000.00
CONFIRMATION: y = 0.19956922 < t/d

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

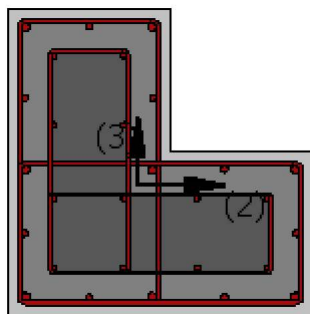
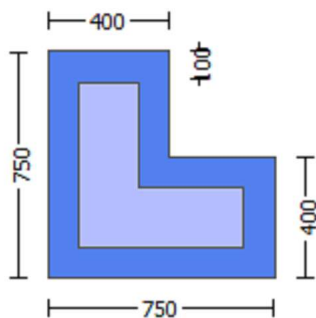
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( 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: rcjlcs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary 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 = 1.00

Element Length,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -0.0005439$

EDGE -B-

Shear Force,  $V_b = 0.0005439$

## BOTH EDGES

Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 1137.257$

-Compression:  $As_{c,com} = 2362.478$

-Middle:  $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$  with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 8.4307E+008$

$Mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 8.4307E+008$

$Mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $Mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5055191E-006$

$M_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

$\phi_c (5A.5, \text{TB DY}) = 0.002$

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TB DY:  $\phi_u = 0.00791261$

we (5.4c)  $= 0.01216945$

$ase ((5.4d), \text{TB DY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$

$ase1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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).

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 2.92621$

Expression (5.4d) for  $p_{sh,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  (5.4d) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (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:  $c_c = 0.002$

$c = \text{confinement factor} = 1.00$

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 \cdot esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_1 = (f_{s,jacket} \cdot A_{sl,ten,jacket} + f_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with  $Es_1 = (E_{s,jacket} \cdot A_{sl,ten,jacket} + E_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y_2 = 0.00140044$

$sh_2 = 0.0044814$

$ft_2 = 442.4791$

$fy_2 = 368.7326$

$su_2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 \cdot esu2_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu2_{nominal} = 0.08$ ,

For calculation of  $esu2_{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.

$y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = (f_{s,jacket} \cdot A_{sl,com,jacket} + f_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 368.7326$

with  $Es_2 = (E_{s,jacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

```

yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914

```

and confined core properties:

```

b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191

```

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

```

--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006

```

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

```

u = 9.3115772E-006
Mu = 8.4307E+008

```

with full section properties:

```

b = 400.00
d = 707.00
d' = 43.00
v = 0.00174912
N = 16323.501
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261
we (5.4c) = 0.01216945
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$lo/lo_{min} = lb/l_d = 0.30$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$$

```

    with Es1 = (Esjacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
    y2 = 0.00140044
    sh2 = 0.0044814
    ft2 = 441.538
    fy2 = 367.9484
    su2 = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 0.30
    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 = 367.9484
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
    yv = 0.00140044
    shv = 0.0044814
    ftv = 431.8911
    fyv = 359.9093
    suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
    v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
    and confined core properties:
    b = 340.00
    d = 677.00
    d' = 13.00
    fcc (5A.2, TBDY) = 33.00
    cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
    v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
    Case/Assumption: Unconfined full section - Steel rupture
    ' satisfies Eq. (4.3)
    --->
    v < vs,y2 - LHS eq.(4.5) is satisfied
    --->
    su (4.9) = 0.22227278
    Mu = MRc (4.14) = 8.4307E+008
    u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+



Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 8.5055191E-006$$

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\phi_{co}(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.00791261$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.00791261$$

$$\phi_{we}(5.4c) = 0.01216945$$

$$\phi_{ase}((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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  $b_i d_i / 6$  as defined at (A.2).

$$\phi_{ase2} (\geq \phi_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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).

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$$

$$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\phi_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5A.5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket * Asl, \text{ten}, \text{jacket} + fs\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 367.9484$   
 with  $Es1 = (Es\_jacket * Asl, \text{ten}, \text{jacket} + Es\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 0.30$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs\_jacket * Asl, \text{com}, \text{jacket} + fs\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 368.7326$   
 with  $Es2 = (Es\_jacket * Asl, \text{com}, \text{jacket} + Es\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 0.30$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl, \text{mid}, \text{jacket} + fs\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 359.9093$   
 with  $Es_v = (Es\_jacket * Asl, \text{mid}, \text{jacket} + Es\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.02391392$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.04978341$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05078914$   
 and confined core properties:  
 $b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.02714524$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.05651029$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.05765191$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

---

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

---->

$$s_u(4.9) = 0.14856848$$

$$M_u = M_{Rc}(4.14) = 5.0139E+008$$

$$u = s_u(4.1) = 8.5055191E-006$$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $M_{u2}$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 9.3115772E-006$$

$$M_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.00791261$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.00791261$$

$$w_e(5.4c) = 0.01216945$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.45746528$$

$$a_{se1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 2.92621$$

$$p_{sh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1}(\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1}(\text{stirrups area}) = 78.53982$$

$$p_{sh2}(5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

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 = 0.002  
c = confinement factor = 1.00

y1 = 0.00140044  
sh1 = 0.0044814  
ft1 = 442.4791  
fy1 = 368.7326  
su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 = 368.7326

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044  
sh2 = 0.0044814

ft2 = 441.538  
fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 367.9484

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044  
shv = 0.0044814

ftv = 431.8911  
fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 0.30

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 = 359.9093

$$\text{with } E_{sv} = (E_{s,jacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.09334389$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.04483889$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, \text{TBDY}) = 33.00$$

$$c_c (5A.5, \text{TBDY}) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.11468265$$

$$2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.05508886$$

$$v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$\mu_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/d$

Inadequate Lap Length with  $l_b/d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), \text{ASCE 41-17}) = k_{nl} \cdot V_{Col0}$$

$$V_{Col0} = 998297.143$$

$k_{nl} = 1$  (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:  $f'_c = (f'_c \cdot A_{jacket} + f'_c \cdot A_{core}) / A_{section} = 27.68182$ , but  $f_c^{0.5} \leq 8.3 \text{ MPa}$  (22.5.3.1, ACI 318-14)

$$M/Vd = 4.00$$

$$\mu_u = 326.4029$$

$$V_u = 0.0005439$$

$$d = 0.8 \cdot h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s,jacket} + V_{s,core} = 881489.011$$

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  $Col_{c2} = 0.00$

$$s/d = 1.5625$$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 838832.606$

$$bw = 400.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$

$$V_{ColO} = 998297.143$$

$knl = 1$  (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)

$$M/Vd = 4.00$$

$$\mu_u = 326.4024$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

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<sub>s,c2</sub> is multiplied by Col,c2 = 0.00  
s/d = 1.5625  
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: 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,  $\gamma$  = 1.00  
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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 = 1.00  
Element Length,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_o/l_{ou,min} = 0.30$   
No FRP Wrapping  
-----

#### Stepwise Properties

-----  
At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -0.0005439$   
EDGE -B-  
Shear Force,  $V_b = 0.0005439$   
BOTH EDGES  
Axial Force,  $F = -16323.501$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 5969.026$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 1137.257$

-Compression:  $A_{sc,com} = 2362.478$

-Middle:  $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$

with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 8.4307E+008$

$\mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 8.4307E+008$

$\mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$\mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of  $\mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 8.5055191E-006$

$\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$

$d = 707.00$

$d' = 43.00$

$\nu = 0.00093286$

$N = 16323.501$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.00791261$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.00791261$

we (5.4c) = 0.01216945

$a_{se}$  ((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).

$psh_{min} \cdot F_{ywe} = \text{Min}(psh_x \cdot F_{ywe}, psh_y \cdot F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh_{min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$

$psh1$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$psh2$  ((5.4d)) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$

$psh1$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$psh2$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s2) = 0.00067082$

$L_{stir2}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 441.538$

$fy1 = 367.9484$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou_{min} = lb/ld = 0.30$

$su1 = 0.4 \cdot esu1_{nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $esu1_{nominal} = 0.08$ ,

For calculation of  $esu1_{nominal}$  and  $y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} \cdot A_{sl,ten,jacket} + fs_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 367.9484$

with  $Es1 = (Es_{jacket} \cdot A_{sl,ten,jacket} + Es_{core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 442.4791$

$fy2 = 368.7326$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$lo/lou_{min} = lb/lb_{min} = 0.30$

$su2 = 0.4 \cdot esu2_{nominal}$  ((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  $fs2 = (fs_{jacket} \cdot A_{sl,com,jacket} + fs_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 368.7326$

with  $Es2 = (Es_{jacket} \cdot A_{sl,com,jacket} + Es_{core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$

$yv = 0.00140044$

$shv = 0.0044814$

```

ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 0.30
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
    2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
    v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
    c = confinement factor = 1.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
    2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
    v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->
su (4.9) = 0.14856848
Mu = MRc (4.14) = 5.0139E+008
u = su (4.1) = 8.5055191E-006
-----

Calculation of ratio lb/ld
-----
Inadequate Lap Length with lb/ld = 0.30
-----
-----
Calculation of Mu1-
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 9.3115772E-006
Mu = 8.4307E+008
-----
with full section properties:
b = 400.00
d = 707.00
d' = 43.00
v = 0.00174912
N = 16323.501
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.00791261
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.00791261
we (5.4c) = 0.01216945
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

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of the rectangular sections confinement, which is expressed by (5.4d).

The generalization is done according to Mander, J., Priestley, M., and Park, R. (1988)

"Theoretical Stress-Strain Model for Confined Concrete."

J. Struct. Eng., 10.1061/(ASCE)0733-9445(1988)114:8(1804), 1804-1826.

$A_{conf,max1} = 353600.00$  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).

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

-----  
 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1$  ((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), TBDY) =  $L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$

$L_{stir2}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su1 = 0.4 * esu1_{nominal}$  ((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  $fs1 = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 368.7326$

with  $Es1 = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$

$y2 = 0.00140044$

```

sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 0.30
    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 = 367.9484
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb = 0.30
    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 = 359.9093
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886
v = Asl,mid/(b*d)*(fsv/fc) = 0.11699947
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is satisfied
--->
su (4.9) = 0.22227278
Mu = MRc (4.14) = 8.4307E+008
u = su (4.1) = 9.3115772E-006

```

Calculation of ratio lb/lb

Inadequate Lap Length with lb/lb = 0.30

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 8.5055191E-006

$$\mu = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\alpha (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, \alpha) = 0.00791261$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu = 0.00791261$$

$$\mu_e (5.4c) = 0.01216945$$

$$\alpha_e ((5.4d), \text{TB DY}) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.45746528$$

$$\alpha_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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).

$$\alpha_2 (> \alpha_1) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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).

$$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $p_{sh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along Y}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} (5.4d) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along Y}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 2.92621$$

$$p_{sh1} ((5.4d), \text{TB DY}) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} (\text{Length of stirrups along X}) = 2060.00$$

$$A_{stir1} (\text{stirrups area}) = 78.53982$$

$$p_{sh2} ((5.4d), \text{TB DY}) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} (\text{Length of stirrups along X}) = 1468.00$$

$$A_{stir2} (\text{stirrups area}) = 50.26548$$

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.002$$

$$\alpha_c = \text{confinement factor} = 1.00$$

```

y1 = 0.00140044
sh1 = 0.0044814
ft1 = 441.538
fy1 = 367.9484
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 367.9484
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 442.4791
fy2 = 368.7326
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 368.7326
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02391392
2 = Asl,com/(b*d)*(fs2/fc) = 0.04978341
v = Asl,mid/(b*d)*(fsv/fc) = 0.05078914
and confined core properties:
b = 690.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.02714524
2 = Asl,com/(b*d)*(fs2/fc) = 0.05651029
v = Asl,mid/(b*d)*(fsv/fc) = 0.05765191
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is satisfied
---->

```

$s_u(4.9) = 0.14856848$   
 $\mu_u = M_{Rc}(4.14) = 5.0139E+008$   
 $u = s_u(4.1) = 8.5055191E-006$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2}$ -

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$   
 $\mu_u = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$

$f_c = 33.00$

$\phi_c(5A.5, TBDY) = 0.002$

Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.00791261$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_{cu} = 0.00791261$

$\phi_{we}(5.4c) = 0.01216945$

$\phi_{ase}((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.45746528$

$\phi_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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).

$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 2.92621$

Expression (5.4d) for  $\phi_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 2.92621$

$\phi_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$

$L_{stir1}$  (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

$psh\_yFywe = psh1*Fywe1 + ps2*Fywe2 = 2.92621$   
 $psh1 ((5.4d), TBDY) = Lstir1*Astir1/(Asec*s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along X)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 ((5.4d), TBDY) = Lstir2*Astir2/(Asec*s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along X)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

Asec = 440000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.4444

fywe2 = 555.5556

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 442.4791

fy1 = 368.7326

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

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 = 368.7326

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 441.538

fy2 = 367.9484

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 367.9484

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

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 = 359.9093

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.09334389



$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.04483859$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.09522963$$

and confined core properties:

$$b = 340.00$$

$$d = 677.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 33.00$$

$$c_c (5A.5, TBDY) = 0.002$$

$$c = \text{confinement factor} = 1.00$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u (4.9) = 0.22227278$$

$$M_u = M_{Rc} (4.14) = 8.4307E+008$$

$$u = s_u (4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$$

$$V_{Col0} = 998297.143$$

$$k_{nl} = 1 \text{ (zero step-static loading)}$$

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} = f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$$= 1 \text{ (normal-weight concrete)}$$

$$\text{Mean concrete strength: } f'_c = (f'_{c\_jacket} * \text{Area}_{jacket} + f'_{c\_core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182, \text{ but } f_c^{0.5} \leq 8.3 \text{ MPa (22.5.3.1, ACI 318-14)}$$

$$M/Vd = 4.00$$

$$M_u = 326.5735$$

$$V_u = 0.0005439$$

$$d = 0.8 * h = 600.00$$

$$N_u = 16323.501$$

$$A_g = 300000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{sjacket} + V_{s,core} = 881489.011$$

where:

$$V_{sjacket} = V_{sj1} + V_{sj2} = 802851.456$$

$V_{sj1} = 279252.68$  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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$   
 $V_{ColO} = 998297.143$   
 $knl = 1$  (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)  
 $M/Vd = 4.00$   
 $M_u = 326.5741$   
 $V_u = 0.0005439$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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  $Col,c2 = 1.00$   
 $s/d = 0.56818182$

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: 2  
Integration Section: (b)  
Section Type: rcjls

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
Existing material of Secondary 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,  $L = 3000.00$   
Secondary Member  
Ribbed Bars  
Ductile Steel  
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -84132.56$   
Shear Force,  $V_2 = 6543.324$   
Shear Force,  $V_3 = -93.37449$   
Axial Force,  $F = -16953.648$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st,ten} = 1137.257$   
-Compression:  $A_{st,com} = 2362.478$   
-Middle:  $A_{st,mid} = 2469.292$   
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:  $A_{sl,com,core} = 615.7522$

-Middle:  $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $DbL = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = u = 0.03973817$

$u = y + p = 0.03973817$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00076575 ((4.29), \text{Biskinis Phd})$

$M_y = 3.6946E+008$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 901.023

From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} * E_c * I_g = 1.4491E+014$

factor = 0.30

$A_g = 440000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 27.68182$

$N = 16953.648$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  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,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 2.5827092E-006$

with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 291.9465$

$d = 707.00$

$y = 0.2005739$

$A = 0.01136652$

$B = 0.00499529$

with  $pt = 0.00434791$

$pc = 0.0044554$

$pv = 0.00465684$

$N = 16953.648$

$b = 750.00$

" = 0.06082037

$y_{comp} = 1.5663957E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.19866014$

$A = 0.01118434$

$B = 0.00488577$

with  $E_s = 200000.00$

CONFIRMATION:  $y = 0.19956922 < t/d$

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03897242$

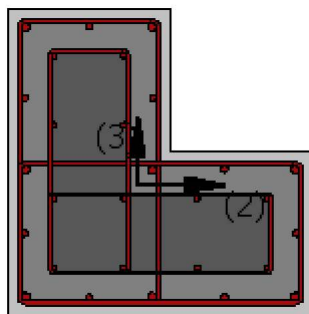
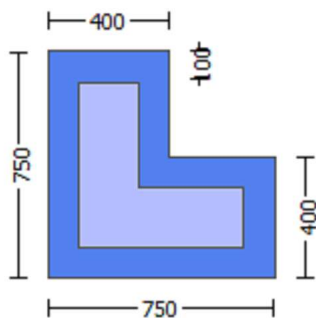
with:

- Columns controlled by inadequate development or splicing along the clear height because  $l_b/l_d < 1$   
shear control ratio  $V_{yE}/V_{ColOE} = 0.56300412$   
 $d = d_{external} = 707.00$   
 $s = s_{external} = 0.00$   
-  $t = s_1 + s_2 + 2 \cdot t_f/bw \cdot (f_{fe}/f_s) = 0.00434791$   
jacket:  $s_1 = A_{v1} \cdot L_{stir1}/(s_1 \cdot A_g) = 0.00367709$   
 $A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction  
 $L_{stir1} = 2060.00$ , 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  $2 \cdot t_f/bw \cdot (f_{fe}/f_s)$  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.  
 $NUD = 16953.648$   
 $A_g = 440000.00$   
 $f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core})/section\_area = 27.68182$   
 $f_{yE} = (f_{y,ext\_Long\_Reinf} \cdot Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot Area_{int\_Long\_Reinf})/Area_{Tot\_Long\_Rein} = 521.1696$   
 $f_{yE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2)/(s_1 + s_2) = 538.4128$   
 $\rho_l = Area_{Tot\_Long\_Rein}/(b \cdot d) = 0.011257$   
 $b = 750.00$   
 $d = 707.00$   
 $f_{cE} = 27.68182$

-----  
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: Collapse Prevention (data interpolation between analysis steps 1 and 2)  
Analysis: Uniform +X  
Check: Shear capacity  $V_{Rd}$   
Edge: End  
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)

Section Type: rcjls

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

Existing material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 16.00$

Existing material of Secondary 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,  $L = 3000.00$

Secondary Member

Ribbed Bars

Ductile Steel

Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_o/l_{ou,min} = l_b/l_d = 0.30$

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -194177.576$

Shear Force,  $V_a = 93.37449$   
 EDGE -B-  
 Bending Moment,  $M_b = -84132.56$   
 Shear Force,  $V_b = -93.37449$   
 BOTH EDGES  
 Axial Force,  $F = -16953.648$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{st} = 0.00$   
   -Compression:  $A_{sc} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{st,ten} = 1137.257$   
   -Compression:  $A_{sc,com} = 2362.478$   
   -Middle:  $A_{sc,mid} = 2469.292$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = \phi V_n = 1.0165E+006$   
 $V_n ((10.3), ASCE 41-17) = knl * V_{ColO} = 1.0165E+006$   
 $V_{Col} = 1.0165E+006$   
 $knl = 1.00$   
 $displacement\_ductility\_demand = 4.1282056E-005$

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).

$\phi = 1$  (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)  
 $M/Vd = 2.00$   
 $M_u = 84132.56$   
 $V_u = 93.37449$   
 $d = 0.8 * h = 600.00$   
 $N_u = 16953.648$   
 $A_g = 300000.00$   
 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  $\theta = 3.1611559E-008$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.00076575 ((4.29), Biskinis\ Phd)$   
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 901.023  
 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:  $f'_c = (f'_{c\_jacket} * Area_{jacket} + f'_{c\_core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16953.648$   
 $E_c * I_g = E_{c\_jacket} * I_{g\_jacket} + E_{c\_core} * I_{g\_core} = 4.8303E+014$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

Assuming neutral axis within flange ( $\phi_y < t/d$ , compression zone rectangular) with:  
 flange width,  $b = 750.00$   
 web width,  $bw = 400.00$   
 flange thickness,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827092E-006$   
 with  $((10.1), ASCE\ 41-17)$   $f_y = \text{Min}(f_y, 1.25 * f_y * (I_b / I_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.2005739$   
 $A = 0.01136652$   
 $B = 0.00499529$   
 with  $pt = 0.00214476$   
 $pc = 0.0044554$   
 $pv = 0.00465684$   
 $N = 16953.648$   
 $b = 750.00$   
 $\phi_y = 0.06082037$   
 $y_{comp} = 1.5663957E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866014$   
 $A = 0.01118434$   
 $B = 0.00488577$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $\phi_y = 0.19956922 < t/d$

Calculation of ratio  $I_b / I_d$

Inadequate Lap Length with  $I_b / I_d = 0.30$

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

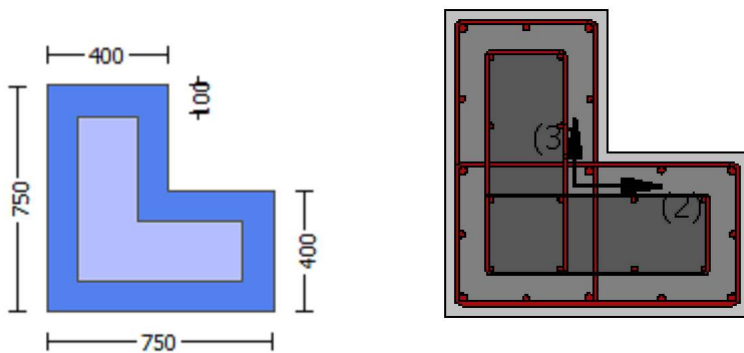
Limit State: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$

Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{st} = 0.00$   
   -Compression:  $A_{sc} = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{st,ten} = 1137.257$   
   -Compression:  $A_{sc,com} = 2362.478$   
   -Middle:  $A_{st,mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 8.4307E+008$   
 $\mu_{u1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 8.4307E+008$   
 $\mu_{u2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $\mu_{u1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5055191E-006$   
 $M_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$

$co$  (5A.5, TBDY) = 0.002  
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.00791261$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.00791261$   
 $we$  (5.4c) = 0.01216945  
 $ase$  ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.45746528$   
 $ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$   
 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).  
 $ase2 (>= ase1) = Max(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$   
 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).  
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$   
 Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$   
 $psh1$  ((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 ((5A5), TBDY), TBDY:  $cc = 0.002$   
 $c$  = confinement factor = 1.00

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{min} = lb/d = 0.30$

$su1 = 0.4 \cdot esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 367.9484$   
 with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/lb, min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 368.7326$   
 with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 359.9093$   
 with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14856848$

$Mu = MRc (4.14) = 5.0139E+008$

$u = su (4.1) = 8.5055191E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

## Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 9.3115772\text{E-}006$$

$$\text{Mu} = 8.4307\text{E+}008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu = \text{shear\_factor} * \text{Max}(\mu_c, \mu_o) = 0.00791261$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.00791261$$

$$\mu_o \text{ (5.4c)} = 0.01216945$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase1} * \text{Aext} + \text{ase2} * \text{Aint}) / \text{Asec} = 0.45746528$$

$$\text{ase1} = \text{Max}(((\text{Aconf,max1} - \text{AnoConf1}) / \text{Aconf,max1}) * (\text{Aconf,min1} / \text{Aconf,max1}), 0) = 0.45746528$$

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).

$$\text{ase2} (> = \text{ase1}) = \text{Max}(((\text{Aconf,max2} - \text{AnoConf2}) / \text{Aconf,max2}) * (\text{Aconf,min2} / \text{Aconf,max2}), 0) = 0.45746528$$

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).

$$\text{psh,min} * \text{Fywe} = \text{Min}(\text{psh,x} * \text{Fywe}, \text{psh,y} * \text{Fywe}) = 2.92621$$

Expression (5.4d) for psh,min\*Fywe has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\text{psh}_x * \text{Fywe} = \text{psh1} * \text{Fywe1} + \text{ps2} * \text{Fywe2} = 2.92621$$

$$\text{psh1 ((5.4d), TBDY)} = \text{Lstir1} * \text{Astir1} / (\text{Asec} * s1) = 0.00367709$$

$$\text{Lstir1 (Length of stirrups along Y)} = 2060.00$$

$$\text{Astir1 (stirrups area)} = 78.53982$$

$$\text{psh2 (5.4d)} = \text{Lstir2} * \text{Astir2} / (\text{Asec} * s2) = 0.00067082$$

$$\text{Lstir2 (Length of stirrups along Y)} = 1468.00$$

$$\text{Astir2 (stirrups area)} = 50.26548$$

$$\text{psh}_y * \text{Fywe} = \text{psh1} * \text{Fywe1} + \text{ps2} * \text{Fywe2} = 2.92621$$

$$\text{psh1 ((5.4d), TBDY)} = \text{Lstir1} * \text{Astir1} / (\text{Asec} * s1) = 0.00367709$$

$$\text{Lstir1 (Length of stirrups along X)} = 2060.00$$

$$\text{Astir1 (stirrups area)} = 78.53982$$

$$\text{psh2 ((5.4d), TBDY)} = \text{Lstir2} * \text{Astir2} / (\text{Asec} * s2) = 0.00067082$$

$$\text{Lstir2 (Length of stirrups along X)} = 1468.00$$

$$\text{Astir2 (stirrups area)} = 50.26548$$

```

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 = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 442.4791
fy1 = 368.7326
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
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 = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 0.30
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 = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00

```

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.11468265$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.05508886$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.11699947$$

Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$$s_u(4.9) = 0.22227278$$

$$\mu_u = M_{Rc}(4.14) = 8.4307E+008$$

$$u = s_u(4.1) = 9.3115772E-006$$

Calculation of ratio  $l_b/l_d$

Inadequate Lap Length with  $l_b/l_d = 0.30$

Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 8.5055191E-006$$

$$\mu_u = 5.0139E+008$$

with full section properties:

$$b = 750.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00093286$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$\alpha_{co}(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.00791261$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.00791261$$

$$\mu_{we}(5.4c) = 0.01216945$$

$$\mu_{ase}((5.4d), TBDY) = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\mu_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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).

$$\mu_{ase2}(>= \mu_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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).

$$\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $\mu_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh\_x \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along Y)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 \text{ (5.4d)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along Y)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

$psh\_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 2.92621$   
 $psh1 \text{ ((5.4d), TBDY)} = Lstir1 \cdot Astir1 / (Asec \cdot s1) = 0.00367709$   
 $Lstir1 \text{ (Length of stirrups along X)} = 2060.00$   
 $Astir1 \text{ (stirrups area)} = 78.53982$   
 $psh2 \text{ ((5.4d), TBDY)} = Lstir2 \cdot Astir2 / (Asec \cdot s2) = 0.00067082$   
 $Lstir2 \text{ (Length of stirrups along X)} = 1468.00$   
 $Astir2 \text{ (stirrups area)} = 50.26548$

$Asec = 440000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.4444$   
 $fywe2 = 555.5556$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$   
 $c = \text{confinement factor} = 1.00$

$y1 = 0.00140044$   
 $sh1 = 0.0044814$   
 $ft1 = 441.538$   
 $fy1 = 367.9484$   
 $su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.30$

$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 367.9484$

with  $Es1 = (Es\_jacket \cdot Asl, ten, jacket + Es\_core \cdot Asl, ten, core) / Asl, ten = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lou, min = lb/lb, min = 0.30$

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 368.7326$

with  $Es2 = (Es\_jacket \cdot Asl, com, jacket + Es\_core \cdot Asl, com, core) / Asl, com = 200000.00$

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lou, min = lb/ld = 0.30$

$suv = 0.4 \cdot esuv\_nominal \text{ ((5.5), TBDY)} = 0.032$



From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv$ ,  $shv$ ,  $ftv$ ,  $fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1$ ,  $sh1$ ,  $ft1$ ,  $fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02391392$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.04978341$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc$  (5A.2, TBDY) = 33.00  
 $cc$  (5A.5, TBDY) = 0.002  
 $c$  = confinement factor = 1.00  
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.02714524$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.05651029$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

---->  
 $v < vs_{y2}$  - LHS eq.(4.5) is satisfied

---->  
 $su$  (4.9) = 0.14856848  
 $Mu = MRc$  (4.14) = 5.0139E+008  
 $u = su$  (4.1) = 8.5055191E-006

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$   
 $Mu = 8.4307E+008$

with full section properties:

$b = 400.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00174912$   
 $N = 16323.501$

$fc = 33.00$   
 $co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = shear\_factor \cdot Max(cu, cc) = 0.00791261$

The  $Shear\_factor$  is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00791261$

we (5.4c) = 0.01216945

$ase$  ((5.4d), TBDY) =  $(ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase1 = Max(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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).  
 $ase2 (>= ase1) = \text{Max}(((A_{conf,max2} - \text{AnoConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$

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).

$psh,min * F_{ywe} = \text{Min}(psh,x * F_{ywe}, psh,y * F_{ywe}) = 2.92621$

Expression (5.4d) for  $psh,min * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$psh,x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$

$psh1 ((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$

$L_{stir1}$  (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:  $cc = 0.002$

$c$  = confinement factor = 1.00

$y1 = 0.00140044$

$sh1 = 0.0044814$

$ft1 = 442.4791$

$fy1 = 368.7326$

$su1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su1 = 0.4 * esu1_{nominal} ((5.5), TBDY) = 0.032$

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  $fs1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 368.7326$

with  $Es1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$

$y2 = 0.00140044$

$sh2 = 0.0044814$

$ft2 = 441.538$

$fy2 = 367.9484$

$su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$

$su_2 = 0.4 \cdot esu_{2\_nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2\_nominal} = 0.08$ ,  
 For calculation of  $esu_{2\_nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$   
 with  $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$   
 $y_v = 0.00140044$   
 $sh_v = 0.0044814$   
 $ft_v = 431.8911$   
 $fy_v = 359.9093$   
 $suv = 0.00512$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lo_{u,min} = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fs_v/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$   
 with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.09334389$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.04483859$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.09522963$

and confined core properties:

$b = 340.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11468265$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05508886$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.22227278$

$\mu_u = MR_c (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$

$V_{Col0} = 998297.143$

$knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_s + f^* V_f$ '  
 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)

$M/Vd = 4.00$   
 $\mu_u = 326.4029$   
 $\nu_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$   
 $V_{Col0} = 998297.143$   
 $knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$   
 $\mu_u = 326.4024$   
 $\nu_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary 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 Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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 = 1.00  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Inadequate Lap Length with  $l_o/l_{o,min} = 0.30$   
 No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -0.0005439$   
 EDGE -B-  
 Shear Force,  $V_b = 0.0005439$   
 BOTH EDGES  
 Axial Force,  $F = -16323.501$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 5969.026$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 1137.257$   
   -Compression:  $As_{c,com} = 2362.478$   
   -Middle:  $As_{mid} = 2469.292$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.56300412$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 562045.409$   
 with  
 $M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 8.4307E+008$   
 $\mu_{1+} = 5.0139E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{1-} = 8.4307E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 8.4307E+008$   
 $\mu_{2+} = 5.0139E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{2-} = 8.4307E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $\mu_{1+}$

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\phi_u = 8.5055191E-006$   
 $\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $\phi_o$  (5A.5, TBDY) = 0.002  
 Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \max(\phi_u, \phi_o) = 0.00791261$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $c_u = 0.00791261$

$w_e$  (5.4c) = 0.01216945

$a_{se}$  ((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).

$a_{se2} (>= a_{se1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) \cdot (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$

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).

$p_{sh,min} \cdot F_{ywe} = \text{Min}(p_{sh,x} \cdot F_{ywe}, p_{sh,y} \cdot F_{ywe}) = 2.92621$

Expression (5.4d) for  $p_{sh,min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$p_{sh,x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along Y) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  (5.4d) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (Length of stirrups along Y) = 1468.00

$A_{stir2}$  (stirrups area) = 50.26548

$p_{sh,y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 2.92621$

$p_{sh1}$  ((5.4d), TBDY) =  $L_{stir1} \cdot A_{stir1} / (A_{sec} \cdot s_1) = 0.00367709$

$L_{stir1}$  (Length of stirrups along X) = 2060.00

$A_{stir1}$  (stirrups area) = 78.53982

$p_{sh2}$  ((5.4d), TBDY) =  $L_{stir2} \cdot A_{stir2} / (A_{sec} \cdot s_2) = 0.00067082$

$L_{stir2}$  (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:  $c_c = 0.002$

$c$  = confinement factor = 1.00

$y_1 = 0.00140044$

$sh_1 = 0.0044814$

$ft_1 = 441.538$

$fy_1 = 367.9484$

$su_1 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 0.30$

$su_1 = 0.4 \cdot e_{su1\_nominal}$  ((5.5), TBDY) = 0.032

From table 5A.1, TBDY:  $e_{su1\_nominal} = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs_{jacket} \cdot Asl_{ten,jacket} + fs_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 367.9484$

with  $Es1 = (Es_{jacket} \cdot Asl_{ten,jacket} + Es_{core} \cdot Asl_{ten,core}) / Asl_{ten} = 200000.00$

$y2 = 0.00140044$   
 $sh2 = 0.0044814$   
 $ft2 = 442.4791$   
 $fy2 = 368.7326$   
 $su2 = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou,min = lb/lb,min = 0.30$   
 $su2 = 0.4 \cdot esu2\_nominal \cdot ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 368.7326$

with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$yv = 0.00140044$   
 $shv = 0.0044814$   
 $ftv = 431.8911$   
 $fyv = 359.9093$   
 $suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lou,min = lb/ld = 0.30$   
 $suv = 0.4 \cdot esuv\_nominal \cdot ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY

For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.02391392$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.04978341$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.05078914$

and confined core properties:

$b = 690.00$   
 $d = 677.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 33.00$   
 $cc (5A.5, TBDY) = 0.002$   
 $c = \text{confinement factor} = 1.00$   
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.02714524$   
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.05651029$   
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y2$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.14856848$   
 $Mu = MRc (4.14) = 5.0139E+008$   
 $u = su (4.1) = 8.5055191E-006$

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$



## Calculation of Mu1-

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 9.3115772E-006$$

$$\mu_u = 8.4307E+008$$

with full section properties:

$$b = 400.00$$

$$d = 707.00$$

$$d' = 43.00$$

$$v = 0.00174912$$

$$N = 16323.501$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.00791261$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.00791261$$

$$\mu_{ue}(5.4c) = 0.01216945$$

$$\mu_{ase}((5.4d), TBDY) = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.45746528$$

$$\mu_{ase1} = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) * (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$$

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).

$$\mu_{ase2} (>= \mu_{ase1}) = \text{Max}(((A_{conf,max2} - A_{noConf2}) / A_{conf,max2}) * (A_{conf,min2} / A_{conf,max2}), 0) = 0.45746528$$

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).

$$\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $\mu_{psh,min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$\mu_{psh,x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.92621$$

$$\mu_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\mu_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$\mu_{psh,y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 2.92621$$

$$\mu_{psh1}((5.4d), TBDY) = L_{stir1} * A_{stir1} / (A_{sec} * s_1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$\mu_{psh2}((5.4d), TBDY) = L_{stir2} * A_{stir2} / (A_{sec} * s_2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s_1 = 100.00$$

```

s2 = 250.00
fywe1 = 694.4444
fywe2 = 555.5556
fce = 33.00
From ((5A5), TBDY), TBDY: cc = 0.002
c = confinement factor = 1.00
y1 = 0.00140044
sh1 = 0.0044814
ft1 = 442.4791
fy1 = 368.7326
su1 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 0.30
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 368.7326
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.00140044
sh2 = 0.0044814
ft2 = 441.538
fy2 = 367.9484
su2 = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 0.30
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 367.9484
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.00140044
shv = 0.0044814
ftv = 431.8911
fyv = 359.9093
suv = 0.00512
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 0.30
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 359.9093
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.09334389
2 = Asl,com/(b*d)*(fs2/fc) = 0.04483859
v = Asl,mid/(b*d)*(fsv/fc) = 0.09522963
and confined core properties:
b = 340.00
d = 677.00
d' = 13.00
fcc (5A.2, TBDY) = 33.00
cc (5A.5, TBDY) = 0.002
c = confinement factor = 1.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.11468265
2 = Asl,com/(b*d)*(fs2/fc) = 0.05508886

```

$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.11699947$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)

--->  
 $v < v_{s, y2}$  - LHS eq.(4.5) is satisfied  
--->  
 $\mu_u (4.9) = 0.22227278$   
 $\mu_u = M_{Rc} (4.14) = 8.4307E+008$   
 $u = \mu_u (4.1) = 9.3115772E-006$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

Calculation of  $\mu_{u2+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $u = 8.5055191E-006$   
 $\mu_u = 5.0139E+008$

with full section properties:

$b = 750.00$   
 $d = 707.00$   
 $d' = 43.00$   
 $v = 0.00093286$   
 $N = 16323.501$   
 $f_c = 33.00$   
 $\alpha (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} \cdot \text{Max}(\mu_u, \mu_c) = 0.00791261$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.00791261$   
 $\mu_{ue} (5.4c) = 0.01216945$   
 $\mu_{ase} ((5.4d), TBDY) = (\mu_{ase1} \cdot A_{ext} + \mu_{ase2} \cdot A_{int}) / A_{sec} = 0.45746528$   
 $\mu_{ase1} = \text{Max}(((A_{conf, max1} - A_{noConf1}) / A_{conf, max1}) \cdot (A_{conf, min1} / A_{conf, max1}), 0) = 0.45746528$   
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).  
 $\mu_{ase2} (>= \mu_{ase1}) = \text{Max}(((A_{conf, max2} - A_{noConf2}) / A_{conf, max2}) \cdot (A_{conf, min2} / A_{conf, max2}), 0) = 0.45746528$   
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).  
 $\mu_{psh, min} \cdot F_{ywe} = \text{Min}(\mu_{psh, x} \cdot F_{ywe}, \mu_{psh, y} \cdot F_{ywe}) = 2.92621$   
Expression (5.4d) for  $\mu_{psh, min} \cdot F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$\mu_{psh, x} \cdot F_{ywe} = \mu_{psh1} \cdot F_{ywe1} + \mu_{psh2} \cdot F_{ywe2} = 2.92621$

$psh1 ((5.4d), TBDY) = Lstir1 * Astir1 / (Asec * s1) = 0.00367709$   
 $Lstir1$  (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 = 0.002

c = confinement factor = 1.00

y1 = 0.00140044

sh1 = 0.0044814

ft1 = 441.538

fy1 = 367.9484

su1 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

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 = 367.9484

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.00140044

sh2 = 0.0044814

ft2 = 442.4791

fy2 = 368.7326

su2 = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 0.30

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 = 368.7326

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.00140044

shv = 0.0044814

ftv = 431.8911

fyv = 359.9093

suv = 0.00512

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/ld = 0.30

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  $fs_v = fsv/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.02391392$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.04978341$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05078914$

and confined core properties:

$b = 690.00$

$d = 677.00$

$d' = 13.00$

$fcc$  (5A.2, TBDY) = 33.00

$cc$  (5A.5, TBDY) = 0.002

$c$  = confinement factor = 1.00

$1 = Asl_{ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.02714524$

$2 = Asl_{com} / (b \cdot d) \cdot (fs_2 / fc) = 0.05651029$

$v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.05765191$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su$  (4.9) = 0.14856848

$Mu = MRc$  (4.14) = 5.0139E+008

$u = su$  (4.1) = 8.5055191E-006

Calculation of ratio  $lb/ld$

Inadequate Lap Length with  $lb/ld = 0.30$

Calculation of  $Mu_2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 9.3115772E-006$

$Mu = 8.4307E+008$

with full section properties:

$b = 400.00$

$d = 707.00$

$d' = 43.00$

$v = 0.00174912$

$N = 16323.501$

$fc = 33.00$

$co$  (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} \cdot \text{Max}(cu, cc) = 0.00791261$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $cu = 0.00791261$

$w_e$  (5.4c) = 0.01216945

$ase$  ((5.4d), TBDY) =  $(ase_1 \cdot A_{ext} + ase_2 \cdot A_{int}) / A_{sec} = 0.45746528$

$ase_1 = \text{Max}(((A_{conf,max1} - A_{noConf1}) / A_{conf,max1}) \cdot (A_{conf,min1} / A_{conf,max1}), 0) = 0.45746528$

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  $bi^2/6$  as defined at (A.2).

$$ase2 (>=ase1) = \text{Max}(((A_{conf,max2}-A_{noConf2})/A_{conf,max2}) * (A_{conf,min2}/A_{conf,max2}), 0) = 0.45746528$$

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).

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 2.92621$$

Expression (5.4d) for  $psh_{min} * F_{ywe}$  has been multiplied by 0.3 according to 15.7.1.3 for members without earthquake detailing (90° closed stirrups)

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along Y)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ (5.4d)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along Y)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 2.92621$$

$$psh1 \text{ ((5.4d), TBDY)} = L_{stir1} * A_{stir1} / (A_{sec} * s1) = 0.00367709$$

$$L_{stir1} \text{ (Length of stirrups along X)} = 2060.00$$

$$A_{stir1} \text{ (stirrups area)} = 78.53982$$

$$psh2 \text{ ((5.4d), TBDY)} = L_{stir2} * A_{stir2} / (A_{sec} * s2) = 0.00067082$$

$$L_{stir2} \text{ (Length of stirrups along X)} = 1468.00$$

$$A_{stir2} \text{ (stirrups area)} = 50.26548$$

$$A_{sec} = 440000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.4444$$

$$f_{ywe2} = 555.5556$$

$$f_{ce} = 33.00$$

From ((5.A5), TBDY), TBDY:  $cc = 0.002$

$c$  = confinement factor = 1.00

$$y1 = 0.00140044$$

$$sh1 = 0.0044814$$

$$ft1 = 442.4791$$

$$fy1 = 368.7326$$

$$su1 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_d = 0.30$$

$$su1 = 0.4 * esu1_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

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.

$$\text{with } fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 368.7326$$

$$\text{with } Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$$

$$y2 = 0.00140044$$

$$sh2 = 0.0044814$$

$$ft2 = 441.538$$

$$fy2 = 367.9484$$

$$su2 = 0.00512$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$$l_o/l_{ou,min} = l_b/l_{b,min} = 0.30$$

$$su2 = 0.4 * esu2_{nominal} \text{ ((5.5), TBDY)} = 0.032$$

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  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 367.9484$

with  $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.00140044$

$sh_v = 0.0044814$

$ft_v = 431.8911$

$fy_v = 359.9093$

$suv = 0.00512$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$lo/lo_{u,min} = lb/ld = 0.30$

$suv = 0.4 \cdot es_{u\_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{u\_nominal} = 0.08$ ,

considering characteristic value  $fs_v = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $es_{u\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $fs_v = fs_v/1.2$ , 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.

with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 359.9093$

with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.09334389$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.04483859$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.09522963$

and confined core properties:

$b = 340.00$

$d = 677.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 33.00$

$cc (5A.5, TBDY) = 0.002$

$c = \text{confinement factor} = 1.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.11468265$

$2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.05508886$

$v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.11699947$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is satisfied

--->

$su (4.9) = 0.22227278$

$Mu = MR_c (4.14) = 8.4307E+008$

$u = su (4.1) = 9.3115772E-006$

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Calculation of ratio  $lb/ld$

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Inadequate Lap Length with  $lb/ld = 0.30$

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Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 998297.143$

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Calculation of Shear Strength at edge 1,  $V_{r1} = 998297.143$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{Col0}$

$V_{Col0} = 998297.143$

$knl = 1$  (zero step-static loading)

-----

NOTE: In expression (10-3) ' $V_s = A_v \cdot fy \cdot d/s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

-----

$= 1$  (normal-weight concrete)

Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$Mu = 326.5735$

$V_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 998297.143$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl \cdot V_{ColO}$   
 $V_{ColO} = 998297.143$   
 $knl = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
 where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 27.68182$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 4.00$   
 $\mu_u = 326.5741$   
 $V_u = 0.0005439$   
 $d = 0.8 \cdot h = 600.00$   
 $N_u = 16323.501$   
 $A_g = 300000.00$   
 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  $Col,j1 = 1.00$



$s/d = 0.3125$   
 $V_{s,j2} = 523598.776$  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:  $V_s + V_f \leq 838832.606$   
 $bw = 400.00$

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 End Of Calculation of Shear Capacity ratio for element: column JLC1 of floor 1  
 At local axis: 2  
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-----  
 Start Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1  
 At local axis: 3  
 Integration Section: (b)  
 Section Type: rcjls

Constant Properties

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 Knowledge Factor,  $\gamma = 1.00$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.5556$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 Existing material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 20.00$   
 Existing material of Secondary 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,  $L = 3000.00$   
 Secondary Member  
 Ribbed Bars  
 Ductile Steel  
 Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections

Inadequate Lap Length with  $l_b/l_d = 0.30$   
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = 87505.349$   
Shear Force,  $V_2 = 6543.324$   
Shear Force,  $V_3 = -93.37449$   
Axial Force,  $F = -16953.648$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 5969.026$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 1137.257$   
-Compression:  $As_{c,com} = 2362.478$   
-Middle:  $As_{mid} = 2469.292$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,jacket} = 829.3805$   
-Compression:  $As_{c,com,jacket} = 1746.726$   
-Middle:  $As_{mid,jacket} = 1545.664$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,core} = 307.8761$   
-Compression:  $As_{c,com,core} = 615.7522$   
-Middle:  $As_{mid,core} = 923.6282$   
Mean Diameter of Tension Reinforcement,  $Db_L = 16.80$

Existing component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = u = 0.03922738$   
 $u = y + p = 0.03922738$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00025496$  ((4.29), Biskinis Phd))  
 $M_y = 3.6946E+008$   
 $L_s = M/V$  (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:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 27.68182$   
 $N = 16953.648$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 4.8303E+014$

#### Calculation of Yielding Moment $M_y$

Calculation of  $y$  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,  $t = 400.00$

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 2.5827092E-006$   
with ((10.1), ASCE 41-17)  $f_y = \text{Min}(f_y, 1.25 * f_y * (l_b/l_d)^{2/3}) = 291.9465$   
 $d = 707.00$   
 $y = 0.2005739$   
 $A = 0.01136652$   
 $B = 0.00499529$   
with  $pt = 0.00434791$   
 $pc = 0.0044554$   
 $p_v = 0.00465684$

$N = 16953.648$   
 $b = 750.00$   
 $" = 0.06082037$   
 $y_{comp} = 1.5663957E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.19866014$   
 $A = 0.01118434$   
 $B = 0.00488577$   
 with  $E_s = 200000.00$   
 CONFIRMATION:  $y = 0.19956922 < t/d$

Calculation of ratio  $I_b/I_d$

Inadequate Lap Length with  $I_b/I_d = 0.30$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03897242$

with:

- Columns controlled by inadequate development or splicing along the clear height because  $I_b/I_d < 1$

shear control ratio  $V_y E / V_{col} E = 0.56300412$

$d = d_{external} = 707.00$

$s = s_{external} = 0.00$

-  $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00434791$

jacket:  $s_1 = A_{v1} * L_{stir1} / (s_1 * A_g) = 0.00367709$

$A_{v1} = 78.53982$ , is the area of every stirrup parallel to loading (shear) direction

$L_{stir1} = 2060.00$ , is the total Length of all stirrups parallel to loading (shear) direction

$s_1 = 100.00$

core:  $s_2 = A_{v2} * L_{stir2} / (s_2 * A_g) = 0.00067082$

$A_{v2} = 50.26548$ , 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  $2 * t_f / b_w * (f_{fe} / f_s)$  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.

$N_{UD} = 16953.648$

$A_g = 440000.00$

$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section\_area = 27.68182$

$f_{yE} = (f_{y,ext\_Long\_Reinf} * Area_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} * Area_{int\_Long\_Reinf}) / Area_{Tot\_Long\_Rein} = 521.1696$

$f_{yE} = (f_{y,ext\_Trans\_Reinf} * s_1 + f_{y,int\_Trans\_Reinf} * s_2) / (s_1 + s_2) = 538.4128$

$p_l = Area_{Tot\_Long\_Rein} / (b * d) = 0.011257$

$b = 750.00$

$d = 707.00$

$f_{cE} = 27.68182$

End Of Calculation of Chord Rotation Capacity for element: column JLC1 of floor 1

At local axis: 3

Integration Section: (b)