

# Detailed Member Calculations

**Units: N&mm**

**Regulation: ASCE 41-17**

## Calculation No. 1

column C1, Floor 1

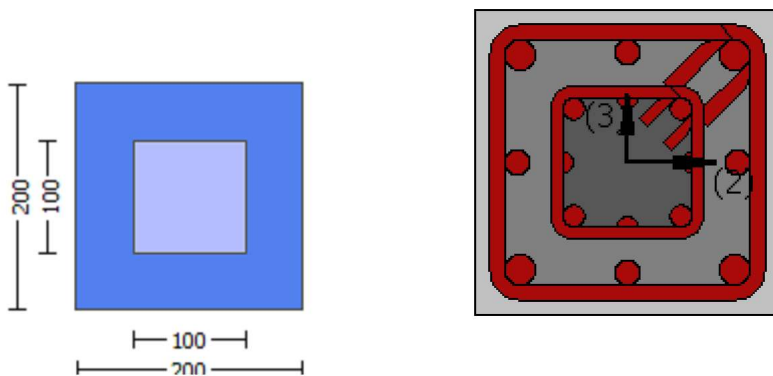
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity  $VR_d$

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of  $\gamma$  for displacement ductility demand,  
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as  
Deformation-Controlled Action (Table C7-1, ASCE 41-17).  
Jacket  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
Existing Column  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
#####  
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -1.1120E+008$   
Shear Force,  $V_a = -31530.033$   
EDGE -B-  
Bending Moment,  $M_b = -6.2875E+006$   
Shear Force,  $V_b = 31530.033$   
BOTH EDGES  
Axial Force,  $F = -218376.72$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl} = 2001.195$   
-Compression:  $A_{slc} = 1291.195$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 983.3185$   
-Compression:  $A_{sl,com} = 983.3185$   
-Middle:  $A_{sl,mid} = 1325.752$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 141974.841$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 141974.841$   
 $V_{CoI} = 141974.841$   
 $k_n = 1.00$   
displacement\_ductility\_demand = 0.38472951

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

= 1 (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_c\_jacket \cdot Area\_jacket + f'_c\_core \cdot Area\_core) / Area\_section = 25.00$ , but  $f'_c^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$   
 $\mu_u = 1.1120E+008$   
 $V_u = 31530.033$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 218376.72$   
 $A_g = 40000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$   
 where:  
 $V_{s1} = 125663.706$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $\text{Col1} = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $\text{Col2} = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 106288.613$   
 $b_w = 200.00$

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  $\theta_r = 0.0348697$   
 $y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.09063433 ((4.29), \text{Biskinis Phd})$   
 $M_y = 1.0142E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 3526.931  
 From table 10.5, ASCE 41\_17:  $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.3155E+012$   
 $\text{factor} = 0.36543691$   
 $A_g = 40000.00$   
 Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot \text{Area}_{jacket} + f'_{c\_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 33.00$   
 $N = 218376.72$   
 $E_c \cdot I_g = E_{c\_jacket} \cdot I_{g\_jacket} + E_{c\_core} \cdot I_{g\_core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 3.1090581E-005$   
 with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48055007$   
 $A = 0.10713558$   
 $B = 0.06707136$   
 with  $p_t = 0.02858484$   
 $p_c = 0.02858484$   
 $p_v = 0.03853931$   
 $N = 218376.72$   
 $b = 200.00$   
 $\rho = 0.1627907$   
 $y_{\text{comp}} = 2.6245742E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48735376$

A = 0.08128164  
B = 0.05564476  
with Es = 200000.00

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

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

At local axis: 2

Integration Section: (a)

## Calculation No. 2

column C1, Floor 1

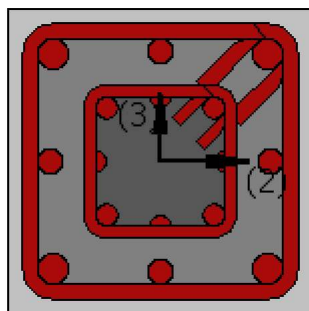
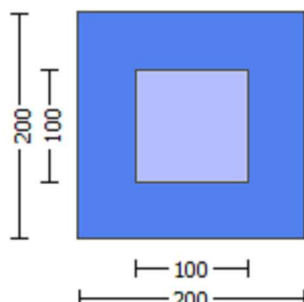
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

```

Existing Column
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
External Height,  $H = 200.00$ 
External Width,  $W = 200.00$ 
Internal Height,  $H = 100.00$ 
Internal Width,  $W = 100.00$ 
Cover Thickness,  $c = 10.00$ 
Mean Confinement Factor overall section = 1.06329
Element Length,  $L = 3000.00$ 
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou}, \min > 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -8.1187678E-030$ 
EDGE -B-
Shear Force,  $V_b = 8.1187678E-030$ 
BOTH EDGES
Axial Force,  $F = -219397.073$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $As_t = 0.00$ 
  -Compression:  $As_c = 3292.389$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $As_{t,ten} = 983.3185$ 
  -Compression:  $As_{c,com} = 983.3185$ 
  -Middle:  $As_{mid} = 1325.752$ 
-----
-----

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.4563967$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$ 
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$ 
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$ 
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

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

```

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

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$\phi_{ue} \text{ (5.4c)} = 0.03096488$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$\phi_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.15233$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.15233$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.15233$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 833.34$$

$$f_{y1} = 694.45$$

$$s_{u1} = 0.032$$

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

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

$$s_{u1} = 0.4 * s_{u1\_nominal} \text{ ((5.5), TBDY)} = 0.032$$

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  $Min(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs1 = (fs\_jacket*Asl,ten,jacket + fs\_core*Asl,ten,core)/Asl,ten = 694.45$   
with  $Es1 = (Es\_jacket*Asl,ten,jacket + Es\_core*Asl,ten,core)/Asl,ten = 200000.00$   
 $y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $lo/lou,min = lb/lb,min = 1.00$   
 $su2 = 0.4*esu2\_nominal ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs2 = (fs\_jacket*Asl,com,jacket + fs\_core*Asl,com,core)/Asl,com = 694.45$   
with  $Es2 = (Es\_jacket*Asl,com,jacket + Es\_core*Asl,com,core)/Asl,com = 200000.00$   
 $yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $lo/lou,min = lb/ld = 1.00$   
 $suv = 0.4*esuv\_nominal ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fsv = (fs\_jacket*Asl,mid,jacket + fs\_mid*Asl,mid,core)/Asl,mid = 694.45$   
with  $Es_v = (Es\_jacket*Asl,mid,jacket + Es\_mid*Asl,mid,core)/Asl,mid = 200000.00$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188$   
and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517$   
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517$   
 $v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < vs,y2$  - LHS eq.(4.5) is not satisfied  
--->  
 $v < vs,c$  - RHS eq.(4.5) is not satisfied  
--->  
Case/Assumption Rejected.  
--->  
New Case/Assumption: Unconfined full section - Spalling of concrete cover  
' satisfies Eq. (4.4)  
--->  
 $v < s,y1$  - LHS eq.(4.7) is not satisfied  
--->  
 $v < vc,y1$  - RHS eq.(4.6) is satisfied

```

---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

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

-----

Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----

Calculation of Mu1-

-----

-----

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

u = 3.2469244E-005  
Mu = 1.3727E+008

-----

with full section properties:

```

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233

```



$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 $No \text{ stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 $No \text{ stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

$From ((5A5), TBDY), TBDY: cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

$using (30) \text{ in Biskinis/Fardis (2013) multiplied with shear\_factor}$   
 $\text{and also multiplied by the shear\_factor according to 15.7.1.4, with}$   
 $Shear\_factor = 1.00$   
 $lo/lou,min = lb/l_d = 1.00$

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

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

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

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

$\text{with } fs1 = (fs,jacket \cdot Asl,ten,jacket + fs,core \cdot Asl,ten,core) / Asl,ten = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

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

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

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

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

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

$\text{with } fs2 = (fs,jacket \cdot Asl,com,jacket + fs,core \cdot Asl,com,core) / Asl,com = 694.45$

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

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$

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

```

lo/lo,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

```

Calculation of ratio lb/d

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

Calculation of  $\mu_{2+}$

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

$$\mu = 3.2469244E-005$$

$$\mu_{2+} = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$\nu = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_{cu}: \mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{co}) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \mu_{cu} = 0.01053874$$

$$\mu_{we} \text{ (5.4c)} = 0.03096488$$

$$\mu_{ase} \text{ ((5.4d), TBDY)} = (\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.16608997$$

$$\mu_{ase1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 6.15233$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 6.15233$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{psh2} * F_{ywe2} = 6.15233$$

$$\mu_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\mu_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

```

fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.

```

```

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
 $v < s_y1$  - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $\epsilon_{cu}$  (4.10) = 0.45915168
 $M_{Rc}$  (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$ 
-  $N$ ,  $1$ ,  $2$ ,  $v$  normalised to  $b_o*d_o$ , instead of  $b*d$ 
- - parameters of confined concrete,  $f_{cc}$ ,  $\epsilon_{cc}$ , used in lieu of  $f_c$ ,  $\epsilon_{cu}$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*s_y2$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*s_c$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*c_y2$  - LHS eq.(4.6) is satisfied
---->
 $\epsilon^*_{cu}$  (4.12) = 0.51649622
 $M_{Ro}$  (4.16) = 1.3727E+008
---->
 $u = \epsilon_{cu}$  (4.2) = 3.2469244E-005
 $\mu = M_{Ro}$ 
-----

Calculation of ratio  $I_b/I_d$ 
-----

Adequate Lap Length:  $I_b/I_d \geq 1$ 
-----

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

-----
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:
 $u = 3.2469244E-005$ 
 $\mu = 1.3727E+008$ 
-----

with full section properties:
 $b = 200.00$ 
 $d = 172.00$ 
 $d' = 28.00$ 
 $v = 0.19326733$ 
 $N = 219397.073$ 
 $f_c = 33.00$ 
 $\epsilon_{co}$  (5A.5, TBDY) = 0.002
Final value of  $\epsilon_{cu}$ :  $\epsilon_{cu}^* = \text{shear\_factor} * \text{Max}(\epsilon_{cu}, \epsilon_{cc}) = 0.01053874$ 
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY:  $\epsilon_{cu} = 0.01053874$ 
 $\epsilon_{we}$  (5.4c) = 0.03096488
 $\epsilon_{ase}$  ((5.4d), TBDY) =  $(\epsilon_{ase1} * A_{ext} + \epsilon_{ase2} * A_{int}) / A_{sec} = 0.16608997$ 
 $\epsilon_{ase1} = 0.16608997$ 
 $b_{o\_1} = 170.00$ 
 $h_{o\_1} = 170.00$ 
 $b_{i2\_1} = 115600.00$ 

```

$ase2 = \text{Max}(ase1, ase2) = 0.16608997$   
 $bo\_2 = 92.00$   
 $ho\_2 = 92.00$   
 $bi2\_2 = 33856.00$   
 $psh, min*Fywe = \text{Min}(psh, x*Fywe, psh, y*Fywe) = 6.15233$

$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$   
 $Ash2 = Astir\_2*ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$   
 $Ash2 = Astir\_2*ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

$\text{From } ((5.A5), \text{TB DY}), \text{TB DY: } cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, min = lb/ld = 1.00$

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

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

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

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

with  $fs1 = (fs, jacket*Asl, ten, jacket + fs, core*Asl, ten, core)/Asl, ten = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

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

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

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

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

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

with  $fs2 = (fs, jacket*Asl, com, jacket + fs, core*Asl, com, core)/Asl, com = 694.45$

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

$yv = 0.0025$

```

shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
    2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
    v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
    c = confinement factor = 1.06329
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
    2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
    v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
    cu (4.10) = 0.45915168
    MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
    *cu (4.12) = 0.51649622

```

$$M_{Ro} (4.16) = 1.3727E+008$$

--->

$$u = cu (4.2) = 3.2469244E-005$$

$$\mu = M_{Ro}$$

Calculation of ratio  $l_b/l_d$

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

$$\text{Calculation of Shear Strength } V_r = \min(V_{r1}, V_{r2}) = 200506.935$$

$$\text{Calculation of Shear Strength at edge 1, } V_{r1} = 200506.935$$

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

$$V_{Col0} = 200506.935$$

$$k_n l = 1 \text{ (zero step-static loading)}$$

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

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

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

$$M/Vd = 2.00$$

$$\mu = 4.0616465E-011$$

$$V_u = 8.1187678E-030$$

$$d = 0.8 * h = 160.00$$

$$N_u = 219397.073$$

$$A_g = 40000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 139627.457$$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$$d = 160.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.625$$

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

$$d = 80.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 3.125$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 122116.319$$

$$b_w = 200.00$$

$$\text{Calculation of Shear Strength at edge 2, } V_{r2} = 200506.935$$

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

$$V_{Col0} = 200506.935$$

$$k_n l = 1 \text{ (zero step-static loading)}$$

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

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

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

$$M/Vd = 2.00$$

$$\mu = 4.0616465E-011$$

$$V_u = 8.1187678E-030$$



$d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
 where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $b_w = 200.00$

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

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

#### Constant Properties

-----  
 Knowledge Factor,  $\phi = 1.00$   
 Mean strength values are used for both shear and moment calculations.  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Jacket  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 Existing Column  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 #####  
 External Height,  $H = 200.00$   
 External Width,  $W = 200.00$   
 Internal Height,  $H = 100.00$   
 Internal Width,  $W = 100.00$   
 Cover Thickness,  $c = 10.00$   
 Mean Confinement Factor overall section = 1.06329  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Smooth Bars

Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )  
No FRP Wrapping

-----

#### Stepwise Properties

-----

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -1.9686856E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.9686856E-030$   
BOTH EDGES  
Axial Force,  $F = -219397.073$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{c,com} = 983.3185$   
-Middle:  $As_{mid} = 1325.752$

-----

-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$   
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$   
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

-----

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

-----

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 3.2469244E-005$   
 $\mu_u = 1.3727E+008$

-----

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $\phi_c (5A.5, \text{TB DY}) = 0.002$   
Final value of  $\phi_{cu}$ :  $\phi_{cu}^* = \text{shear\_factor} * \max(\phi_{cu}, \phi_{cc}) = 0.01053874$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TB DY:  $\phi_{cu} = 0.01053874$   
 $\phi_{we} (5.4c) = 0.03096488$   
 $\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.16608997$   
 $\phi_{ase1} = 0.16608997$   
 $\phi_{bo\_1} = 170.00$   
 $\phi_{ho\_1} = 170.00$

```

bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

From ((5.A5), TBDY), TBDY: cc = 0.00263293  
c = confinement factor = 1.06329

```

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

```

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

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

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

```

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

```

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
    2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
    v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
    c = confinement factor = 1.06329
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
    2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
    v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
    cu (4.10) = 0.45915168
    MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
    - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
    - N, 1, 2, v normalised to bo*do, instead of b*d
    - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->

```

\*cu (4.12) = 0.51649622  
 M<sub>Ro</sub> (4.16) = 1.3727E+008  
 --->  
 u = cu (4.2) = 3.2469244E-005  
 Mu = M<sub>Ro</sub>

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

-----  
 Adequate Lap Length: lb/l<sub>d</sub> >= 1  
 -----  
 -----

Calculation of Mu1-

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

u = 3.2469244E-005  
 Mu = 1.3727E+008

-----  
 with full section properties:

b = 200.00  
 d = 172.00  
 d' = 28.00  
 v = 0.19326733  
 N = 219397.073  
 f<sub>c</sub> = 33.00  
 co (5A.5, TBDY) = 0.002  
 Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01053874  
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY: cu = 0.01053874  
 we (5.4c) = 0.03096488  
 ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.16608997  
 ase1 = 0.16608997  
 bo\_1 = 170.00  
 ho\_1 = 170.00  
 bi2\_1 = 115600.00  
 ase2 = Max(ase1,ase2) = 0.16608997  
 bo\_2 = 92.00  
 ho\_2 = 92.00  
 bi2\_2 = 33856.00  
 psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 6.15233

-----  
 psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
 ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
 Ash1 = Astir\_1\*ns\_1 = 157.0796  
 No stirups, ns\_1 = 2.00  
 h1 = 200.00  
 ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
 Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

-----  
 psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
 ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
 Ash1 = Astir\_1\*ns\_1 = 157.0796  
 No stirups, ns\_1 = 2.00  
 h1 = 200.00  
 ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
 Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

-----  
 Asec = 40000.00  
 s1 = 100.00  
 s2 = 250.00

$fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 833.34$   
 $fy_1 = 694.45$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1, \text{nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_1, \text{nominal} = 0.08$ ,  
 For calculation of  $esu_1, \text{nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$   
 with  $Es_1 = (Es, \text{jacket} * Asl, \text{ten, jacket} + Es, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 833.34$   
 $fy_2 = 694.45$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su_2 = 0.4 * esu_2, \text{nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_2, \text{nominal} = 0.08$ ,  
 For calculation of  $esu_2, \text{nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$   
 with  $Es_2 = (Es, \text{jacket} * Asl, \text{com, jacket} + Es, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $suv = 0.4 * esuv, \text{nominal} ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esuv, \text{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv, \text{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs, \text{jacket} * Asl, \text{mid, jacket} + fs, \text{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$   
 with  $Es_v = (Es, \text{jacket} * Asl, \text{mid, jacket} + Es, \text{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.60153764$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.60153764$   
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, \text{TBDY}) = 35.08866$   
 $cc (5A.5, \text{TBDY}) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.77530517$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.77530517$   
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 1.0453$

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

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

Case/Assumption Rejected.

---->  
New Case/Assumption: Unconfined full section - Spalling of concrete cover  
' satisfies Eq. (4.4)

---->  
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied  
---->  
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied  
---->

$c_u$  (4.10) = 0.45915168  
 $M_{Rc}$  (4.17) = 1.5179E+008

---->  
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover  
In expressions below, the following modifications have been made  
-  $b$ ,  $d$ ,  $d'$  replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$   
-  $N$ ,  $1$ ,  $2$ ,  $v$  normalised to  $b_o*d_o$ , instead of  $b*d$   
- - parameters of confined concrete,  $f_{cc}$ ,  $c_c$ , used in lieu of  $f_c$ ,  $c_u$

---->  
Subcase: Rupture of tension steel

---->  
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied  
---->  
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied  
---->

Subcase rejected

---->  
New Subcase: Failure of compression zone

---->  
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied  
---->

$*c_u$  (4.12) = 0.51649622  
 $M_{Ro}$  (4.16) = 1.3727E+008

---->  
 $u = c_u$  (4.2) = 3.2469244E-005  
 $\mu_u = M_{Ro}$

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

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

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

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

$u = 3.2469244E-005$   
 $\mu_u = 1.3727E+008$

-----  
with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $c_o$  (5A.5, TBDY) = 0.002  
Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01053874$

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

From (5.4b), TBDY:  $c_u = 0.01053874$

$w_e$  (5.4c) = 0.03096488

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.16608997$

$a_{se1} = 0.16608997$

$b_{o\_1} = 170.00$

$h_{o\_1} = 170.00$

$b_{i2\_1} = 115600.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$

$b_{o\_2} = 92.00$

$h_{o\_2} = 92.00$

$b_{i2\_2} = 33856.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 6.15233$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 6.15233$

$p_{s1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00785398$

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

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

$h_1 = 200.00$

$p_{s2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00100531$

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

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

$h_2 = 100.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 6.15233$

$p_{s1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00785398$

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

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

$h_1 = 200.00$

$p_{s2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00100531$

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

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

$h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00263293$

$c$  = confinement factor = 1.06329

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

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

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

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

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

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

with  $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 694.45$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

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

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



```

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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied

```

```

--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied
--->
 $*cu(4.12) = 0.51649622$ 
 $M_{Ro}(4.16) = 1.3727E+008$ 
--->
 $u = cu(4.2) = 3.2469244E-005$ 
 $\mu = M_{Ro}$ 

```

Calculation of ratio  $l_b/l_d$

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

Calculation of  $\mu_2$ -

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

$u = 3.2469244E-005$   
 $\mu = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $co(5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01053874$   
 $we(5.4c) = 0.03096488$   
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo_1 = 170.00$   
 $ho_1 = 170.00$   
 $bi2_1 = 115600.00$   
 $ase2 = Max(ase1, ase2) = 0.16608997$   
 $bo_2 = 92.00$   
 $ho_2 = 92.00$   
 $bi2_2 = 33856.00$   
 $psh_{min} * F_{ywe} = Min(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1(external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 100.00$

$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1(external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$

Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

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

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/ld = 1.00

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

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

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 694.45

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.60153764

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.60153764

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00

d = 157.00

```

d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

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

-----

Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----

-----

-----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

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

$V_{Co10} = 200506.935$

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

-----

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

= 1 (normal-weight concrete)  
Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0213315E-011$   
 $V_u = 1.9686856E-030$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_n l \cdot V_{Col0}$   
 $V_{Col0} = 200506.935$   
 $k_n l = 1$  (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:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0213315E-011$   
 $V_u = 1.9686856E-030$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $b_w = 200.00$

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

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 2  
Integration Section: (a)  
Section Type: rcjrs

#### Constant Properties

-----

Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d > 1$ )  
No FRP Wrapping  
-----

#### Stepwise Properties

-----

Bending Moment,  $M = -6.6699040E-008$   
Shear Force,  $V_2 = -31530.033$   
Shear Force,  $V_3 = 4.1944085E-011$   
Axial Force,  $F = -218376.72$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_{lt} = 2001.195$   
-Compression:  $As_{lc} = 1291.195$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten} = 983.3185$   
-Compression:  $As_{l,com} = 983.3185$   
-Middle:  $As_{l,mid} = 1325.752$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten,jacket} = 829.3805$   
-Compression:  $As_{l,com,jacket} = 829.3805$   
-Middle:  $As_{l,mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten,core} = 153.938$   
-Compression:  $As_{l,com,core} = 153.938$   
-Middle:  $As_{l,mid,core} = 923.6282$   
Mean Diameter of Tension Reinforcement,  $Db_L = 17.50$   
-----

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0$   $u = 0.04304225$   
 $u = y + p = 0.04304225$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.03854669$  ((4.29), Biskinis Phd))  
 $M_y = 1.0142E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3155E+012$   
 $factor = 0.36543691$   
 $A_g = 40000.00$   
Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 218376.72$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

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

$y = \min(y_{ten}, y_{com})$   
 $y_{ten} = 3.1090581E-005$   
with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48055007$   
 $A = 0.10713558$   
 $B = 0.06707136$   
with  $p_t = 0.02858484$   
 $p_c = 0.02858484$   
 $p_v = 0.03853931$   
 $N = 218376.72$   
 $b = 200.00$   
 $" = 0.1627907$   
 $y_{comp} = 2.6245742E-005$   
with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48735376$   
 $A = 0.08128164$   
 $B = 0.05564476$   
with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00449557$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $I_b/I_d \geq 1$   
shear control ratio  $V_y E / V_{col} E = 0.4563967$   
 $d = d_{external} = 172.00$   
 $s = s_{external} = 150.00$   
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00885929$   
jacket:  $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00785398$   
 $A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h_1 = 200.00$   
 $s_1 = 100.00$   
core:  $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00100531$   
 $A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$$h2 = 100.00$$

$$s2 = 250.00$$

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.

$$N_{UD} = 218376.72$$

$$A_g = 40000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 33.00$$

$$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 555.56$$

$$f_{ytE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$$

$$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.09570899$$

$$b = 200.00$$

$$d = 172.00$$

$$f_{cE} = 33.00$$

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

At local axis: 2

Integration Section: (a)

### Calculation No. 3

column C1, Floor 1

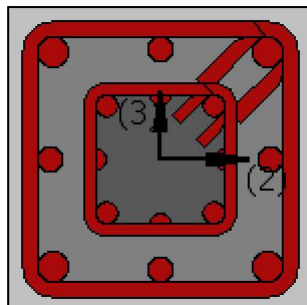
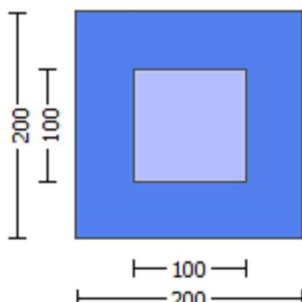
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs



## Constant Properties

Knowledge Factor,  $\phi = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

## Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -6.6699040E-008$

Shear Force,  $V_a = 4.1944085E-011$

EDGE -B-

Bending Moment,  $M_b = -6.0481164E-008$

Shear Force,  $V_b = -4.1944085E-011$

BOTH EDGES

Axial Force,  $F = -218376.72$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 2001.195$

-Compression:  $As_c = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{l,mid} = 1325.752$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 177661.069$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoIO} = 177661.069$

$V_{CoI} = 177661.069$

kn1 = 1.00  
displacement\_ductility\_demand = 0.00

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

= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 6.6699040\text{E-}008$   
 $\nu_u = 4.1944085\text{E-}011$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 218376.72$   
 $A_g = 40000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$   
where:  
 $V_{s1} = 125663.706$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $\text{Col1} = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $\text{Col2} = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$   
From (11-11), ACI 440:  $V_s + V_f \leq 106288.613$   
 $bw = 200.00$

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  $\phi = 2.0709479\text{E-}018$   
 $y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.03854669 ((4.29), \text{Biskinis Phd})$   
 $M_y = 1.0142\text{E+}008$   
 $L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.3155\text{E+}012$   
 $\text{factor} = 0.36543691$   
 $A_g = 40000.00$   
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$   
 $N = 218376.72$   
 $E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 3.5999\text{E+}012$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$   
 $y_{\text{ten}} = 3.1090581\text{E-}005$   
with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48055007$   
 $A = 0.10713558$   
 $B = 0.06707136$   
with  $pt = 0.02858484$

$p_c = 0.02858484$   
 $p_v = 0.03853931$   
 $N = 218376.72$   
 $b = 200.00$   
 $" = 0.1627907$   
 $y_{comp} = 2.6245742E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48735376$   
 $A = 0.08128164$   
 $B = 0.05564476$   
 with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

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

At local axis: 3

Integration Section: (a)

## Calculation No. 4

column C1, Floor 1

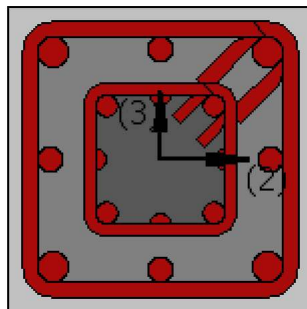
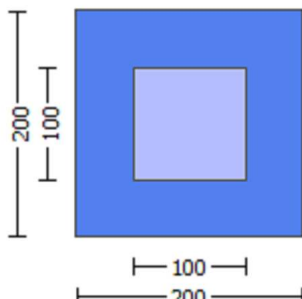
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 1.00$   
 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,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of moment strengths,  
 the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
 Jacket  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 Existing Column  
 New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
 #####  
 External Height,  $H = 200.00$   
 External Width,  $W = 200.00$   
 Internal Height,  $H = 100.00$   
 Internal Width,  $W = 100.00$   
 Cover Thickness,  $c = 10.00$   
 Mean Confinement Factor overall section = 1.06329  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{ou, \min} \geq 1$ )  
 No FRP Wrapping

#### Stepwise Properties

At local axis: 3  
 EDGE -A-  
 Shear Force,  $V_a = -8.1187678E-030$   
 EDGE -B-  
 Shear Force,  $V_b = 8.1187678E-030$   
 BOTH EDGES  
 Axial Force,  $F = -219397.073$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{st} = 0.00$   
 -Compression:  $A_{sc} = 3292.389$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st, \text{ten}} = 983.3185$   
 -Compression:  $A_{st, \text{com}} = 983.3185$   
 -Middle:  $A_{st, \text{mid}} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
 with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3727E+008$   
 $M_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $M_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination

$$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$$

$Mu_{2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3727E+008$ , 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:

$$\phi_u = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_{cu}: \phi_{cu}^* = \text{shear\_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01053874$$

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

$$\text{From (5.4b), TB DY: } \phi_{cu} = 0.01053874$$

$$\phi_{we} (5.4c) = 0.03096488$$

$$\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.16608997$$

$$\phi_{ase1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.15233$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 6.15233$$

$$\phi_{ps1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 6.15233$$

$$\phi_{ps1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi_{cc} = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

```

sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied

```

```

---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
 $v < s_y1$  - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
---->
 $c_u$  (4.10) = 0.45915168
 $M_{Rc}$  (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$ 
-  $N$ ,  $1$ ,  $2$ ,  $v$  normalised to  $b_o*d_o$ , instead of  $b*d$ 
- - parameters of confined concrete,  $f_{cc}$ ,  $c_c$ , used in lieu of  $f_c$ ,  $c_u$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*s_y2$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*s_{c,c}$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*c_{y2}$  - LHS eq.(4.6) is satisfied
---->
 $c_u$  (4.12) = 0.51649622
 $M_{Ro}$  (4.16) = 1.3727E+008
---->
 $u = c_u$  (4.2) = 3.2469244E-005
 $\mu = M_{Ro}$ 
-----

Calculation of ratio  $I_b/I_d$ 
-----
Adequate Lap Length:  $I_b/I_d \geq 1$ 
-----
-----
Calculation of  $\mu_1$ -
-----
-----
Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:
 $u = 3.2469244E-005$ 
 $\mu = 1.3727E+008$ 
-----
with full section properties:
 $b = 200.00$ 
 $d = 172.00$ 
 $d' = 28.00$ 
 $v = 0.19326733$ 
 $N = 219397.073$ 
 $f_c = 33.00$ 
 $c_o$  (5A.5, TBDY) = 0.002
Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01053874$ 
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY:  $c_u = 0.01053874$ 
 $w_e$  (5.4c) = 0.03096488
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.16608997$ 
 $a_{se1} = 0.16608997$ 
 $b_{o\_1} = 170.00$ 

```

$ho\_1 = 170.00$   
 $bi2\_1 = 115600.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$   
 $bo\_2 = 92.00$   
 $ho\_2 = 92.00$   
 $bi2\_2 = 33856.00$   
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 6.15233$

$psh\_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

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

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

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

$\text{with } fs1 = (fs, \text{jacket} * Asl, \text{ten, jacket} + fs, \text{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

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

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

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

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

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

$\text{with } fs2 = (fs, \text{jacket} * Asl, \text{com, jacket} + fs, \text{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$



```

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied

```

--->

$$*cu(4.12) = 0.51649622$$

$$MRo(4.16) = 1.3727E+008$$

--->

$$u = cu(4.2) = 3.2469244E-005$$

$$Mu = MRo$$

Calculation of ratio  $Ib/I_d$

Adequate Lap Length:  $Ib/I_d \geq 1$

Calculation of  $Mu_{2+}$

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

$$u = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$fc = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01053874$$

$$we(5.4c) = 0.03096488$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$$

$$ase1 = 0.16608997$$

$$bo_1 = 170.00$$

$$ho_1 = 170.00$$

$$bi2_1 = 115600.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$

$$bo_2 = 92.00$$

$$ho_2 = 92.00$$

$$bi2_2 = 33856.00$$

$$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$$

$$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 100.00$$

$$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s1 = 100.00$$

$s_2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5A.5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 833.34$   
 $fy_1 = 694.45$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_1 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_1 \text{ nominal}$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$   
 with  $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 833.34$   
 $fy_2 = 694.45$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esu_2 \text{ nominal} = 0.08$ ,  
 For calculation of  $esu_2 \text{ nominal}$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$   
 with  $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$   
 From table 5A.1, TBDY:  $esuv \text{ nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fs_v/1.2$ , 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.  
 $y_v, sh_v, ft_v, fy_v$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_v = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.60153764$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.60153764$   
 $v = Asl, \text{mid} / (b * d) * (fs_v / f_c) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, \text{TBDY}) = 35.08866$   
 $cc (5A.5, \text{TBDY}) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.77530517$   
 $2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.77530517$

```

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

Calculation of Mu2-

-----

-----

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

u = 3.2469244E-005  
Mu = 1.3727E+008

-----

with full section properties:

b = 200.00  
d = 172.00  
d' = 28.00  
v = 0.19326733  
N = 219397.073  
fc = 33.00  
co (5A.5, TBDY) = 0.002

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01053874$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $cu = 0.01053874$   
we (5.4c) = 0.03096488  
ase ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo\_1 = 170.00$   
 $ho\_1 = 170.00$   
 $bi2\_1 = 115600.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$   
 $bo\_2 = 92.00$   
 $ho\_2 = 92.00$   
 $bi2\_2 = 33856.00$   
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1$  (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2$  (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1$  (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2$  (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$A_{sec} = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

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

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

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

with  $fs1 = (fs, \text{jacket} * A_{sl, \text{ten, jacket}} + fs, \text{core} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

```

lo/lou,min = lb/lbu,min = 1.00
su2 = 0.4*esu2,nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2,nominal = 0.08,
For calculation of esu2,nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fsjacket*Aslcom,jacket + fscore*Aslcom,core)/Aslcom = 694.45
with Es2 = (Esjacket*Aslcom,jacket + Escore*Aslcom,core)/Aslcom = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*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 = 694.45
with Esv = (Esjacket*Aslmid,jacket + Esmid*Aslmid,core)/Aslmid = 200000.00
1 = Aslten/(b*d)*(fs1/fc) = 0.60153764
2 = Aslcom/(b*d)*(fs2/fc) = 0.60153764
v = Aslmid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Aslten/(b*d)*(fs1/fc) = 0.77530517
2 = Aslcom/(b*d)*(fs2/fc) = 0.77530517
v = Aslmid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N1, N2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->

```

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

--->

$*c_u$  (4.12) = 0.51649622

$M_{Ro}$  (4.16) = 1.3727E+008

--->

$u = c_u$  (4.2) = 3.2469244E-005

$\mu = M_{Ro}$

Calculation of ratio  $l_b/l_d$

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

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

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

$V_{Col0} = 200506.935$

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

$M/V_d = 2.00$

$\mu_u = 4.0616465E-011$

$V_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

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

$V_{Col0} = 200506.935$

$k_n l = 1$  (zero step-static loading)

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$V_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

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

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

Constant Properties

Knowledge Factor,  $\phi = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####



External Height,  $H = 200.00$   
 External Width,  $W = 200.00$   
 Internal Height,  $H = 100.00$   
 Internal Width,  $W = 100.00$   
 Cover Thickness,  $c = 10.00$   
 Mean Confinement Factor overall section = 1.06329  
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )  
 No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
 EDGE -A-  
 Shear Force,  $V_a = -1.9686856E-030$   
 EDGE -B-  
 Shear Force,  $V_b = 1.9686856E-030$   
 BOTH EDGES  
 Axial Force,  $F = -219397.073$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 3292.389$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 983.3185$   
   -Compression:  $As_{c,com} = 983.3185$   
   -Middle:  $As_{l,mid} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
 with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$   
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$   
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

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

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 3.2469244E-005$   
 $\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$

$co(5A.5, TBDY) = 0.002$   
 Final value of  $cu^* = shear\_factor * Max(cu, cc) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01053874$   
 $we(5.4c) = 0.03096488$   
 $ase((5.4d), TBDY) = (ase1*Aext + ase2*Aint)/Asec = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo\_1 = 170.00$   
 $ho\_1 = 170.00$   
 $bi2\_1 = 115600.00$   
 $ase2 = Max(ase1, ase2) = 0.16608997$   
 $bo\_2 = 92.00$   
 $ho\_2 = 92.00$   
 $bi2\_2 = 33856.00$   
 $psh, min*Fywe = Min(psh, x*Fywe, psh, y*Fywe) = 6.15233$

$psh, x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$   
 $ps1(external) = (Ash1*h1/s1)/Asec = 0.00785398$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2*h2/s2)/Asec = 0.00100531$   
 $Ash2 = Astir\_2*ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$psh, y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$   
 $ps1(external) = (Ash1*h1/s1)/Asec = 0.00785398$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2*h2/s2)/Asec = 0.00100531$   
 $Ash2 = Astir\_2*ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

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

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

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

with  $fs1 = (fs, jacket*Asl, ten, jacket + fs, core*Asl, ten, core)/Asl, ten = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

```

Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*,y2 - LHS eq.(4.5) is not satisfied

```

```

---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/ld
-----

Adequate Lap Length: lb/ld >= 1
-----

Calculation of Mu1-
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00
-----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00

```

$h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

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  $fs1 = (fs\_jacket \cdot Asl, ten, jacket + fs\_core \cdot Asl, ten, core) / Asl, ten = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

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

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

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

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

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

with  $fs2 = (fs\_jacket \cdot Asl, com, jacket + fs\_core \cdot Asl, com, core) / Asl, com = 694.45$

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

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$

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

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

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

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

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

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

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

with  $fsv = (fs\_jacket \cdot Asl, mid, jacket + fs\_mid \cdot Asl, mid, core) / Asl, mid = 694.45$

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

$1 = Asl, ten / (b \cdot d) \cdot (fs1 / fc) = 0.60153764$

$2 = Asl, com / (b \cdot d) \cdot (fs2 / fc) = 0.60153764$

$v = Asl, mid / (b \cdot d) \cdot (fsv / fc) = 0.8110188$

and confined core properties:

```

b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----

Adequate Lap Length: lb/d >= 1
-----

Calculation of Mu2+
-----

-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

```

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi u^* = \text{shear\_factor} * \text{Max}(\phi u, \phi c) = 0.01053874$$

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

$$\text{From (5.4b), TB DY: } \phi u = 0.01053874$$

$$\phi c (5.4c) = 0.03096488$$

$$\phi a_s ((5.4d), \text{TB DY}) = (\phi a_{s1} * A_{ext} + \phi a_{s2} * A_{int}) / A_{sec} = 0.16608997$$

$$\phi a_{s1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$\phi a_{s2} = \text{Max}(\phi a_{s1}, \phi a_{s2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$\phi p_{sh, \min} * F_{ywe} = \text{Min}(\phi p_{sh, x} * F_{ywe}, \phi p_{sh, y} * F_{ywe}) = 6.15233$$

$$\phi p_{sh, x} * F_{ywe} = \phi p_{sh1} * F_{ywe1} + \phi p_{sh2} * F_{ywe2} = 6.15233$$

$$\phi p_{s1} (\text{external}) = (\phi A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi p_{s2} (\text{internal}) = (\phi A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$\phi p_{sh, y} * F_{ywe} = \phi p_{sh1} * F_{ywe1} + \phi p_{sh2} * F_{ywe2} = 6.15233$$

$$\phi p_{s1} (\text{external}) = (\phi A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi p_{s2} (\text{internal}) = (\phi A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \phi c = 0.00263293$$

$$\phi c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

$$\text{Shear\_factor} = 1.00$$

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

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

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

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

characteristic value  $fsy_1 = fs_1 / 1.2$ , from table 5.1, TB DY.

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

$$\text{with } fs_1 = (f_{s, \text{jacket}} * A_{sl, \text{ten, jacket}} + f_{s, \text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 694.45$$

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < sy1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made

```



- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- $N_1, N_2$  v normalised to  $bo \cdot do$ , instead of  $b \cdot d$
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

--->

Subcase: Rupture of tension steel

--->

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

--->

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

--->

$\mu_{cu}$  (4.12) = 0.51649622

M<sub>Ro</sub> (4.16) = 1.3727E+008

--->

$\mu = \mu_{cu}$  (4.2) = 3.2469244E-005

$\mu_u = M_{Ro}$

Calculation of ratio  $l_b/d$

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

Calculation of  $\mu_{u2}$ -

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

$\mu_u = 3.2469244E-005$

$\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

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

Final value of  $\mu_{cu}$ :  $\mu_{cu}^* = \text{shear\_factor} \cdot \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01053874$

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

From (5.4b), TBDY:  $\mu_{cu} = 0.01053874$

$\mu_{we}$  (5.4c) = 0.03096488

$\mu_{ase}$  ((5.4d), TBDY) =  $(\mu_{ase1} \cdot A_{ext} + \mu_{ase2} \cdot A_{int}) / A_{sec} = 0.16608997$

$\mu_{ase1} = 0.16608997$

$\mu_{bo\_1} = 170.00$

$\mu_{ho\_1} = 170.00$

$\mu_{bi2\_1} = 115600.00$

$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.16608997$

$\mu_{bo\_2} = 92.00$

$\mu_{ho\_2} = 92.00$

$\mu_{bi2\_2} = 33856.00$

$\mu_{psh,min} \cdot F_{ywe} = \text{Min}(\mu_{psh,x} \cdot F_{ywe}, \mu_{psh,y} \cdot F_{ywe}) = 6.15233$

$\mu_{psh,x} \cdot F_{ywe} = \mu_{psh1} \cdot F_{ywe1} + \mu_{ps2} \cdot F_{ywe2} = 6.15233$

$\mu_{ps1}$  (external) =  $(\mu_{Ash1} \cdot h_1 / s_1) / A_{sec} = 0.00785398$

$\mu_{Ash1} = \mu_{Astir\_1} \cdot n_{s\_1} = 157.0796$

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

$h_1 = 200.00$

$\mu_{ps2}$  (internal) =  $(\mu_{Ash2} \cdot h_2 / s_2) / A_{sec} = 0.00100531$

$\mu_{Ash2} = \mu_{Astir\_2} \cdot n_{s\_2} = 100.531$

No stirups, ns\_2 = 2.00  
h2 = 100.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 200.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

```

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

-----

-----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

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

$V_{Col0} = 200506.935$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

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

$V_{Col0} = 200506.935$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

d = 80.00  
Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 3.125  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 122116.319  
bw = 200.00

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

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 3

Integration Section: (a)  
Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d \geq 1$ )  
No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = -1.1120E+008$   
Shear Force,  $V2 = -31530.033$   
Shear Force,  $V3 = 4.1944085E-011$   
Axial Force,  $F = -218376.72$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 2001.195$   
-Compression:  $As_c = 1291.195$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{l,ten} = 983.3185$   
-Compression:  $As_{l,com} = 983.3185$   
-Middle:  $As_{l,mid} = 1325.752$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl_{ten,jacket} = 829.3805$   
-Compression:  $Asl_{com,jacket} = 829.3805$   
-Middle:  $Asl_{mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl_{ten,core} = 153.938$   
-Compression:  $Asl_{com,core} = 153.938$   
-Middle:  $Asl_{mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $DbL = 17.50$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.0951299$   
 $u = y + p = 0.0951299$

- Calculation of  $y$  -

$y = (My * L_s / 3) / E_{eff} = 0.09063433$  ((4.29), Biskinis Phd))  
 $My = 1.0142E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3526.931  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3155E+012$   
 $factor = 0.36543691$   
 $Ag = 40000.00$   
Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 218376.72$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $My$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 3.1090581E-005$   
with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48055007$   
 $A = 0.10713558$   
 $B = 0.06707136$   
with  $pt = 0.02858484$   
 $pc = 0.02858484$   
 $pv = 0.03853931$   
 $N = 218376.72$   
 $b = 200.00$   
 $" = 0.1627907$   
 $y_{comp} = 2.6245742E-005$   
with  $fc = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48735376$   
 $A = 0.08128164$   
 $B = 0.05564476$   
with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.00449557$

with:

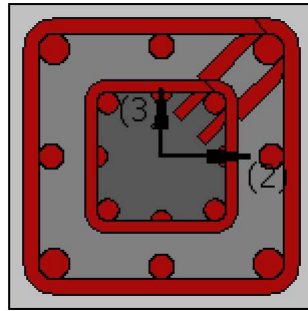
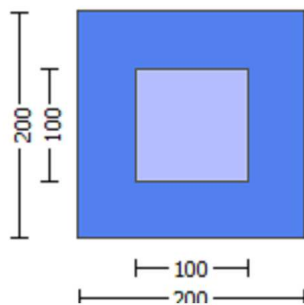
- Columns not controlled by inadequate development or splicing along the clear height because  $I_b/I_d \geq 1$   
shear control ratio  $V_y E / V_{col} I_{OE} = 0.4563967$

$d = d_{\text{external}} = 172.00$   
 $s = s_{\text{external}} = 150.00$   
 $t = s1 + s2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00885929$   
 jacket:  $s1 = A_{v1} \cdot h1 / (s1 \cdot A_g) = 0.00785398$   
 $A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h1 = 200.00$   
 $s1 = 100.00$   
 core:  $s2 = A_{v2} \cdot h2 / (s2 \cdot A_g) = 0.00100531$   
 $A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction  
 $h2 = 100.00$   
 $s2 = 250.00$   
 The term  $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$  is implemented to account for FRP contribution  
 where  $f = 2 \cdot t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength  
 All these variables have already been given in Shear control ratio calculation.  
 For the normalisation  $f_s$  of jacket is used.  
 $NUD = 218376.72$   
 $A_g = 40000.00$   
 $f_{cE} = (f_{c,jacket} \cdot \text{Area}_{jacket} + f_{c,core} \cdot \text{Area}_{core}) / \text{section\_area} = 33.00$   
 $f_{yE} = (f_{y,ext\_Long\_Reinf} \cdot \text{Area}_{ext\_Long\_Reinf} + f_{y,int\_Long\_Reinf} \cdot \text{Area}_{int\_Long\_Reinf}) / \text{Area\_Tot\_Long\_Rein} =$   
 $555.56$   
 $f_{yE} = (f_{y,ext\_Trans\_Reinf} \cdot s1 + f_{y,int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$   
 $\rho_l = \text{Area\_Tot\_Long\_Rein} / (b \cdot d) = 0.09570899$   
 $b = 200.00$   
 $d = 172.00$   
 $f_{cE} = 33.00$

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

## Calculation No. 5

column C1, Floor 1  
 Limit State: Operational Level (data interpolation between analysis steps 50 and 51)  
 Analysis: Uniform +X  
 Check: Shear capacity  $V_{Rd}$   
 Edge: End  
 Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -1.1120E+008$

Shear Force,  $V_a = -31530.033$



EDGE -B-  
 Bending Moment, Mb = -6.2875E+006  
 Shear Force, Vb = 31530.033  
 BOTH EDGES  
 Axial Force, F = -218376.72  
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension: Aslt = 0.00  
   -Compression: Aslc = 3292.389  
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension: Asl,ten = 983.3185  
   -Compression: Asl,com = 983.3185  
   -Middle: Asl,mid = 1325.752  
 Mean Diameter of Tension Reinforcement, DbL,ten = 17.50

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity VR = 1.0\*Vn = 177661.069  
 Vn ((10.3), ASCE 41-17) = knl\*VCol0 = 177661.069  
 VCol = 177661.069  
 knl = 1.00  
 displacement\_ductility\_demand = 1.81332

NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
 where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
 Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 25.00, but  $fc'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 M/Vd = 2.00  
 Mu = 6.2875E+006  
 Vu = 31530.033  
 d = 0.8\*h = 160.00  
 Nu = 218376.72  
 Ag = 40000.00  
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 125663.706  
 where:  
 Vs1 = 125663.706 is calculated for jacket, with:  
   d = 160.00  
   Av = 157079.633  
   fy = 500.00  
   s = 100.00  
 Vs1 is multiplied by Col1 = 1.00  
   s/d = 0.625  
 Vs2 = 0.00 is calculated for core, with:  
   d = 80.00  
   Av = 100530.965  
   fy = 500.00  
   s = 250.00  
 Vs2 is multiplied by Col2 = 0.00  
   s/d = 3.125  
 Vf ((11-3)-(11.4), ACI 440) = 0.00  
 From (11-11), ACI 440: Vs + Vf <= 106288.613  
 bw = 200.00

displacement\_ductility\_demand is calculated as  $\phi / y$

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

From analysis, chord rotation = 0.01397951  
 $y = (My*Ls/3)/Eleff = 0.00770934$  ((4.29),Biskinis Phd))  
 My = 1.0142E+008  
 Ls = M/V (with  $Ls > 0.1*L$  and  $Ls < 2*L$ ) = 300.00  
 From table 10.5, ASCE 41\_17: Eleff = factor\*Ec\*Ig = 1.3155E+012

factor = 0.36543691

Ag = 40000.00

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$

N = 218376.72

$E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 3.5999\text{E}+012$

Calculation of Yielding Moment  $M_y$

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

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

$y_{\text{ten}} = 3.1090581\text{E}-005$

with  $f_y = 555.56$

$d = 172.00$

$y = 0.48055007$

$A = 0.10713558$

$B = 0.06707136$

with  $p_t = 0.02858484$

$p_c = 0.02858484$

$p_v = 0.03853931$

$N = 218376.72$

$b = 200.00$

$" = 0.1627907$

$y_{\text{comp}} = 2.6245742\text{E}-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.48735376$

$A = 0.08128164$

$B = 0.05564476$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

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

At local axis: 2

Integration Section: (b)

## Calculation No. 6

column C1, Floor 1

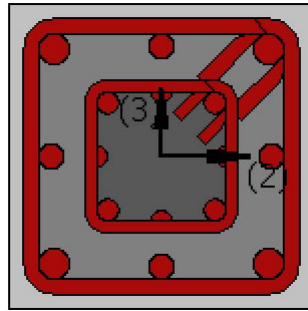
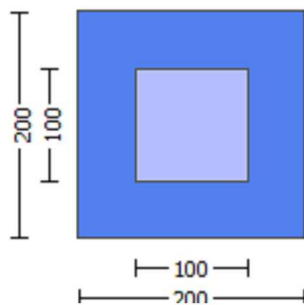
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\theta_r$ )

Edge: End

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force,  $V_a = -8.1187678E-030$

EDGE -B-

Shear Force,  $V_b = 8.1187678E-030$

BOTH EDGES

Axial Force,  $F = -219397.073$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 0.00$   
   -Compression:  $As_c = 3292.389$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 983.3185$   
   -Compression:  $As_{c,com} = 983.3185$   
   -Middle:  $As_{mid} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
 with  
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$   
 $Mu_{1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$   
 $Mu_{2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $Mu_{2-} = 1.3727E+008$ , 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:  
 $\phi_u = 3.2469244E-005$   
 $M_u = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $\phi_c \text{ (5A.5, TBDY)} = 0.002$   
 Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $\phi_u = 0.01053874$   
 $\phi_{ue} \text{ (5.4c)} = 0.03096488$   
 $\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.16608997$   
 $\phi_{se1} = 0.16608997$   
 $b_{o\_1} = 170.00$   
 $h_{o\_1} = 170.00$   
 $b_{i2\_1} = 115600.00$   
 $\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.16608997$   
 $b_{o\_2} = 92.00$   
 $h_{o\_2} = 92.00$   
 $b_{i2\_2} = 33856.00$   
 $\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 6.15233$

$\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.15233$   
 $\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$   
 $A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$   
 No stirups,  $n_{s\_1} = 2.00$   
 $h_1 = 200.00$   
 $\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$   
 $A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$   
 No stirups,  $n_{s\_2} = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh\_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.15233 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir\_1 * ns\_1 = 157.0796 \\ \text{No stirups, } ns\_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00100531 \\ Ash2 &= Astir\_2 * ns\_2 = 100.531 \\ \text{No stirups, } ns\_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

From table 5A.1, TB DY: 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, TB DY.

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

$$\text{with } fs1 = (fs\_jacket * Asl, \text{ten, jacket} + fs\_core * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

From table 5A.1, TB DY: 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, TB DY.

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

$$\text{with } fs2 = (fs\_jacket * Asl, \text{com, jacket} + fs\_core * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
Calculation of Mu1-
-----

```

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

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$\phi_{ue} \text{ (5.4c)} = 0.03096488$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$\phi_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.15233$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.15233$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.15233$$

$$\phi_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 833.34$$

$$f_{y1} = 694.45$$

$$s_{u1} = 0.032$$

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

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

$$\text{Shear\_factor} = 1.00$$

$$I_o / I_{ou, \min} = I_b / I_d = 1.00$$

$$s_{u1} = 0.4 * s_{u1\_nominal} \text{ ((5.5), TBDY)} = 0.032$$

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  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs1 = (fs\_jacket \cdot Asl\_ten\_jacket + fs\_core \cdot Asl\_ten\_core) / Asl\_ten = 694.45$   
with  $Es1 = (Es\_jacket \cdot Asl\_ten\_jacket + Es\_core \cdot Asl\_ten\_core) / Asl\_ten = 200000.00$   
 $y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$   
using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$   
and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 1.00$   
 $su2 = 0.4 \cdot esu2\_nominal ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $fs2 = (fs\_jacket \cdot Asl\_com\_jacket + fs\_core \cdot Asl\_com\_core) / Asl\_com = 694.45$   
with  $Es2 = (Es\_jacket \cdot Asl\_com\_jacket + Es\_core \cdot Asl\_com\_core) / Asl\_com = 200000.00$   
 $yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$   
using (30) in Biskinis/Fardis (2013) multiplied with  $shear\_factor$   
and also multiplied by the  $shear\_factor$  according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 1.00$   
 $suv = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$   
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  $fsv = (fs\_jacket \cdot Asl\_mid\_jacket + fs\_mid \cdot Asl\_mid\_core) / Asl\_mid = 694.45$   
with  $Es_v = (Es\_jacket \cdot Asl\_mid\_jacket + Es\_mid \cdot Asl\_mid\_core) / Asl\_mid = 200000.00$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.60153764$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.60153764$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 0.8110188$   
and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl\_ten / (b \cdot d) \cdot (fs1 / fc) = 0.77530517$   
 $2 = Asl\_com / (b \cdot d) \cdot (fs2 / fc) = 0.77530517$   
 $v = Asl\_mid / (b \cdot d) \cdot (fsv / fc) = 1.0453$   
Case/Assumption: Unconfined full section - Steel rupture  
'satisfies Eq. (4.3)  
--->  
 $v < vs, y2$  - LHS eq.(4.5) is not satisfied  
--->  
 $v < vs, c$  - RHS eq.(4.5) is not satisfied  
--->  
Case/Assumption Rejected.  
--->  
New Case/Assumption: Unconfined full section - Spalling of concrete cover  
'satisfies Eq. (4.4)  
--->  
 $v < s, y1$  - LHS eq.(4.7) is not satisfied  
--->  
 $v < vc, y1$  - RHS eq.(4.6) is satisfied



```

---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

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

-----

Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----

Calculation of Mu<sub>2+</sub>

-----

-----

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

u = 3.2469244E-005  
Mu = 1.3727E+008

-----

with full section properties:

```

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233

```

$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 $No \text{ stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 $No \text{ stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 $No \text{ stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

$From ((5.A5), TBDY), TBDY: cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

with  $fs1 = (fs,jacket \cdot Asl,ten,jacket + fs,core \cdot Asl,ten,core) / Asl,ten = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

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

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

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

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

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

with  $fs2 = (fs,jacket \cdot Asl,com,jacket + fs,core \cdot Asl,com,core) / Asl,com = 694.45$

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

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$

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

```

lo/lo,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

```

Calculation of ratio lb/d

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

Calculation of  $\mu_2$ -

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

$$\mu = 3.2469244E-005$$

$$\mu_2 = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$\nu = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_0 \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu_c, \mu_0) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \mu_c = 0.01053874$$

$$\mu_w \text{ (5.4c)} = 0.03096488$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

```

fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.

```

```

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 200506.935
-----
Calculation of Shear Strength at edge 1, Vr1 = 200506.935
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)
-----
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----
= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.0616465E-011
Vu = 8.1187678E-030
d = 0.8*h = 160.00
Nu = 219397.073
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457
where:
Vs1 = 139627.457 is calculated for jacket, with:
d = 160.00
Av = 157079.633

```

$f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $bw = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$   
 $V_{Col0} = 200506.935$   
 $knl = 1$  (zero step-static loading)

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

$= 1$  (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 4.0616465E-011$   
 $\nu_u = 8.1187678E-030$   
 $d = 0.8 * h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
 where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $bw = 200.00$

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

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

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Mean strength values are used for both shear and moment calculations.  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14  
Jacket  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
Existing Column  
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$   
#####  
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Mean Confinement Factor overall section = 1.06329  
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou, \min} \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -1.9686856E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.9686856E-030$   
BOTH EDGES  
Axial Force,  $F = -219397.073$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{st} = 0.00$   
-Compression:  $A_{sc} = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{st, \text{ten}} = 983.3185$   
-Compression:  $A_{st, \text{com}} = 983.3185$   
-Middle:  $A_{st, \text{mid}} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
with  
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3727E+008$   
 $M_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination  
 $M_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3727E+008$



Mu2+ = 1.3727E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

Mu2- = 1.3727E+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:

$$\phi_u = 3.2469244E-005$$

$$M_u = 1.3727E+008$$

-----  
with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$\phi_{ue} \text{ (5.4c)} = 0.03096488$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$$

$$ase1 = 0.16608997$$

$$bo\_1 = 170.00$$

$$ho\_1 = 170.00$$

$$bi2\_1 = 115600.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$

$$bo\_2 = 92.00$$

$$ho\_2 = 92.00$$

$$bi2\_2 = 33856.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$$

-----  
$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$$

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

$$h2 = 100.00$$

-----  
$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1 \text{ (external)} = (A_{sh1} * h1 / s1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * ns\_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (A_{sh2} * h2 / s2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * ns\_2 = 100.531$$

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

$$h2 = 100.00$$

-----  
$$A_{sec} = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->

```

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

$v < s, y_1$  - LHS eq.(4.7) is not satisfied

--->

$v < v_c, y_1$  - RHS eq.(4.6) is satisfied

--->

$\epsilon_{cu}$  (4.10) = 0.45915168

$M_{Rc}$  (4.17) = 1.5179E+008

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$
- $N$ ,  $\epsilon_1$ ,  $\epsilon_2$ ,  $v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$
- $\epsilon_c$ ,  $\epsilon_{cu}$  parameters of confined concrete,  $\epsilon_{cc}$ ,  $\epsilon_{cu}$  used in lieu of  $\epsilon_c$ ,  $\epsilon_{cu}$

--->

Subcase: Rupture of tension steel

--->

$v^* < v^* s, y_2$  - LHS eq.(4.5) is not satisfied

--->

$v^* < v^* s, c$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^* c, y_2$  - LHS eq.(4.6) is satisfied

--->

$\epsilon^*_{cu}$  (4.12) = 0.51649622

$M_{Ro}$  (4.16) = 1.3727E+008

--->

$\epsilon_u = \epsilon_{cu}$  (4.2) = 3.2469244E-005

$\mu_u = M_{Ro}$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

Calculation of  $\mu_{u1}$ -

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

$\epsilon_u = 3.2469244E-005$

$\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

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

Final value of  $\epsilon_{cu}$ :  $\epsilon_{cu}^* = \text{shear\_factor} \cdot \text{Max}(\epsilon_{cu}, \epsilon_{cc}) = 0.01053874$

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

From (5.4b), TBDY:  $\epsilon_{cu} = 0.01053874$

$\epsilon_{we}$  (5.4c) = 0.03096488

$\epsilon_{ase}$  ((5.4d), TBDY) =  $(\epsilon_{ase1} \cdot A_{ext} + \epsilon_{ase2} \cdot A_{int}) / A_{sec} = 0.16608997$

$\epsilon_{ase1} = 0.16608997$

$b_{o\_1} = 170.00$

$h_{o\_1} = 170.00$

```

bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

From ((5.A5), TBDY), TBDY: cc = 0.00263293  
c = confinement factor = 1.06329

```

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

```

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

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

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

```

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

```

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

```

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
    2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
    v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
    c = confinement factor = 1.06329
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
    2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
    v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
    cu (4.10) = 0.45915168
    MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
    - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
    - N, 1, 2, v normalised to bo*do, instead of b*d
    - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->

```

\*cu (4.12) = 0.51649622  
 M<sub>Ro</sub> (4.16) = 1.3727E+008  
 --->  
 u = cu (4.2) = 3.2469244E-005  
 Mu = M<sub>Ro</sub>

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

-----  
 Adequate Lap Length: lb/l<sub>d</sub> >= 1  
 -----  
 -----

Calculation of Mu<sub>2+</sub>  
 -----

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

u = 3.2469244E-005  
 Mu = 1.3727E+008  
 -----

with full section properties:

b = 200.00  
 d = 172.00  
 d' = 28.00  
 v = 0.19326733  
 N = 219397.073  
 f<sub>c</sub> = 33.00  
 co (5A.5, TBDY) = 0.002  
 Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01053874  
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY: cu = 0.01053874  
 we (5.4c) = 0.03096488  
 ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.16608997  
 ase1 = 0.16608997  
 bo\_1 = 170.00  
 ho\_1 = 170.00  
 bi2\_1 = 115600.00  
 ase2 = Max(ase1,ase2) = 0.16608997  
 bo\_2 = 92.00  
 ho\_2 = 92.00  
 bi2\_2 = 33856.00  
 psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 6.15233

-----  
 psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
 ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
 Ash1 = Astir\_1\*ns\_1 = 157.0796  
 No stirups, ns\_1 = 2.00  
 h1 = 200.00  
 ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
 Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

-----  
 psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
 ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
 Ash1 = Astir\_1\*ns\_1 = 157.0796  
 No stirups, ns\_1 = 2.00  
 h1 = 200.00  
 ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
 Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

-----  
 Asec = 40000.00  
 s1 = 100.00  
 s2 = 250.00

$fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 833.34$   
 $fy_1 = 694.45$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_1\_nominal = 0.08$ ,  
 For calculation of  $esu_1\_nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs_{jacket} * Asl_{ten, jacket} + fs_{core} * Asl_{ten, core}) / Asl_{ten} = 694.45$   
 with  $Es_1 = (Es_{jacket} * Asl_{ten, jacket} + Es_{core} * Asl_{ten, core}) / Asl_{ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 833.34$   
 $fy_2 = 694.45$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 1.00$   
 $su_2 = 0.4 * esu_2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_2\_nominal = 0.08$ ,  
 For calculation of  $esu_2\_nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_2, sh_2, ft_2, fy_2$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs_{jacket} * Asl_{com, jacket} + fs_{core} * Asl_{com, core}) / Asl_{com} = 694.45$   
 with  $Es_2 = (Es_{jacket} * Asl_{com, jacket} + Es_{core} * Asl_{com, core}) / Asl_{com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_v, sh_v, ft_v, fy_v$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl_{mid, jacket} + fs_{mid} * Asl_{mid, core}) / Asl_{mid} = 694.45$   
 with  $Es_v = (Es_{jacket} * Asl_{mid, jacket} + Es_{mid} * Asl_{mid, core}) / Asl_{mid} = 200000.00$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.60153764$   
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.60153764$   
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl_{ten} / (b * d) * (fs_1 / f_c) = 0.77530517$   
 $2 = Asl_{com} / (b * d) * (fs_2 / f_c) = 0.77530517$   
 $v = Asl_{mid} / (b * d) * (fsv / f_c) = 1.0453$

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

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

Case/Assumption Rejected.

--->  
New Case/Assumption: Unconfined full section - Spalling of concrete cover  
' satisfies Eq. (4.4)

--->  
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied  
--->  
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied  
--->

$c_u$  (4.10) = 0.45915168  
 $M_{Rc}$  (4.17) = 1.5179E+008

--->  
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover  
In expressions below, the following modifications have been made  
-  $b$ ,  $d$ ,  $d'$  replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$   
-  $N$ ,  $1$ ,  $2$ ,  $v$  normalised to  $b_o*d_o$ , instead of  $b*d$   
- - parameters of confined concrete,  $f_{cc}$ ,  $c_c$ , used in lieu of  $f_c$ ,  $c_u$

--->  
Subcase: Rupture of tension steel

--->  
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied  
--->  
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied  
--->

Subcase rejected

--->  
New Subcase: Failure of compression zone

--->  
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied  
--->

$*c_u$  (4.12) = 0.51649622  
 $M_{Ro}$  (4.16) = 1.3727E+008

--->  
 $u = c_u$  (4.2) = 3.2469244E-005  
 $M_u = M_{Ro}$

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

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

-----  
Calculation of  $M_{u2}$ -

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

$u = 3.2469244E-005$   
 $M_u = 1.3727E+008$

-----  
with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $c_o$  (5A.5, TBDY) = 0.002  
Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01053874$



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

From (5.4b), TBDY:  $c_u = 0.01053874$

$w_e$  (5.4c) = 0.03096488

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} \cdot A_{ext} + a_{se2} \cdot A_{int}) / A_{sec} = 0.16608997$

$a_{se1} = 0.16608997$

$b_{o\_1} = 170.00$

$h_{o\_1} = 170.00$

$b_{i2\_1} = 115600.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$

$b_{o\_2} = 92.00$

$h_{o\_2} = 92.00$

$b_{i2\_2} = 33856.00$

$p_{sh, \min} \cdot F_{ywe} = \text{Min}(p_{sh, x} \cdot F_{ywe}, p_{sh, y} \cdot F_{ywe}) = 6.15233$

$p_{sh, x} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 6.15233$

$p_{s1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00785398$

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

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

$h_1 = 200.00$

$p_{s2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00100531$

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

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

$h_2 = 100.00$

$p_{sh, y} \cdot F_{ywe} = p_{sh1} \cdot F_{ywe1} + p_{s2} \cdot F_{ywe2} = 6.15233$

$p_{s1}$  (external) =  $(A_{sh1} \cdot h_1 / s_1) / A_{sec} = 0.00785398$

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

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

$h_1 = 200.00$

$p_{s2}$  (internal) =  $(A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00100531$

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

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

$h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $c_c = 0.00263293$

$c$  = confinement factor = 1.06329

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

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

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

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

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

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

with  $fs_1 = (f_{s, \text{jacket}} \cdot A_{s, \text{ten, jacket}} + f_{s, \text{core}} \cdot A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 694.45$

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

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

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

```

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 = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied

```

```

---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied
---->
 $\phi_{cu}$  (4.12) = 0.51649622
 $M_{Ro}$  (4.16) = 1.3727E+008
---->
 $u = \phi_{cu}$  (4.2) = 3.2469244E-005
 $\mu_u = M_{Ro}$ 
-----

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

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 200506.935$ 
-----
Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$ 
 $V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l^* V_{Col0}$ 
 $V_{Col0} = 200506.935$ 
 $k_n l = 1$  (zero step-static loading)
-----
NOTE: In expression (10-3) ' $V_s = A_v \phi_f y^* d/s$ ' is replaced by ' $V_s + \phi_f V_f$ '
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).
-----
= 1 (normal-weight concrete)
Mean concrete strength:  $\phi_c' = (\phi_c'_{jacket} \text{Area}_{jacket} + \phi_c'_{core} \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $\phi_c'^{0.5} \leq 8.3$ 
MPa (22.5.3.1, ACI 318-14)
 $M/V_d = 2.00$ 
 $\mu_u = 2.0213315E-011$ 
 $V_u = 1.9686856E-030$ 
 $d = 0.8 \cdot h = 160.00$ 
 $N_u = 219397.073$ 
 $A_g = 40000.00$ 
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$ 
where:
 $V_{s1} = 139627.457$  is calculated for jacket, with:
 $d = 160.00$ 
 $A_v = 157079.633$ 
 $f_y = 555.56$ 
 $s = 100.00$ 
 $V_{s1}$  is multiplied by  $\phi_{col1} = 1.00$ 
 $s/d = 0.625$ 
 $V_{s2} = 0.00$  is calculated for core, with:
 $d = 80.00$ 
 $A_v = 100530.965$ 
 $f_y = 555.56$ 
 $s = 250.00$ 
 $V_{s2}$  is multiplied by  $\phi_{col2} = 0.00$ 
 $s/d = 3.125$ 
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$ 
 $b_w = 200.00$ 
-----

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$ 
 $V_{r2} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l^* V_{Col0}$ 
 $V_{Col0} = 200506.935$ 
 $k_n l = 1$  (zero step-static loading)
-----
NOTE: In expression (10-3) ' $V_s = A_v \phi_f y^* d/s$ ' is replaced by ' $V_s + \phi_f V_f$ '

```

where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$V_u = 1.9686856E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

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

At local axis: 2

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

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -6.0481164E-008$   
Shear Force,  $V2 = 31530.033$   
Shear Force,  $V3 = -4.1944085E-011$   
Axial Force,  $F = -218376.72$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{c,com} = 983.3185$   
-Middle:  $As_{mid} = 1325.752$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,jacket} = 829.3805$   
-Compression:  $As_{c,com,jacket} = 829.3805$   
-Middle:  $As_{mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,core} = 153.938$   
-Compression:  $As_{c,com,core} = 153.938$   
-Middle:  $As_{mid,core} = 923.6282$   
Mean Diameter of Tension Reinforcement,  $Db_L = 17.50$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.04304225$   
 $u = y + p = 0.04304225$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.03854669$  ((4.29), Biskinis Phd))  
 $M_y = 1.0142E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3155E+012$   
 $factor = 0.36543691$   
 $A_g = 40000.00$   
Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 218376.72$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

#### Calculation of Yielding Moment $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 3.1090581E-005$   
with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48055007$   
 $A = 0.10713558$   
 $B = 0.06707136$   
with  $pt = 0.02858484$   
 $pc = 0.02858484$   
 $pv = 0.03853931$   
 $N = 218376.72$   
 $b = 200.00$

$\rho = 0.1627907$   
 $y_{comp} = 2.6245742E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48735376$   
 $A = 0.08128164$   
 $B = 0.05564476$   
 with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

- Calculation of  $\rho$  -

From table 10-8:  $\rho = 0.00449557$

with:

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

shear control ratio  $V_y E / V_{col} E = 0.4563967$

$d = d_{external} = 172.00$

$s = s_{external} = 150.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00885929$

jacket:  $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00785398$

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

$h_1 = 200.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00100531$

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

$h_2 = 100.00$

$s_2 = 250.00$

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

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

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

For the normalisation  $f_s$  of jacket is used.

$NUD = 218376.72$

$A_g = 40000.00$

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

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

$f_{yE} = (f_{y,ext\_Trans\_Reinf} \cdot s_1 + f_{y,int\_Trans\_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$\rho_l = Area_{Tot\_Long\_Rein} / (b \cdot d) = 0.09570899$

$b = 200.00$

$d = 172.00$

$f_{cE} = 33.00$

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

At local axis: 2

Integration Section: (b)

**Calculation No. 7**

column C1, Floor 1

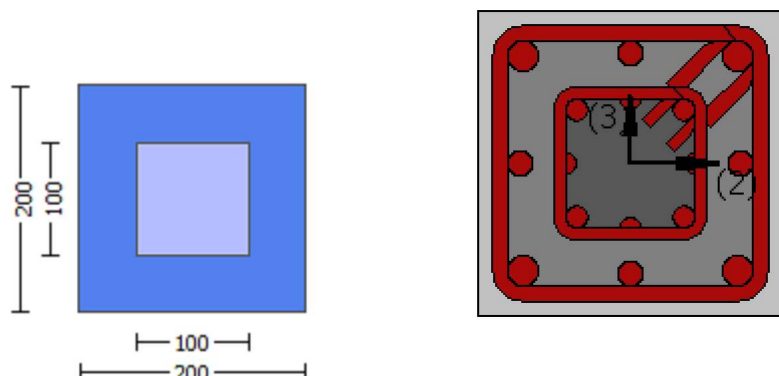
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity  $VR_d$

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{o,u,min} = l_b/l_d \geq 1$ )  
 No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
 Bending Moment,  $M_a = -6.6699040E-008$   
 Shear Force,  $V_a = 4.1944085E-011$   
 EDGE -B-  
 Bending Moment,  $M_b = -6.0481164E-008$   
 Shear Force,  $V_b = -4.1944085E-011$   
 BOTH EDGES  
 Axial Force,  $F = -218376.72$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $A_{sl,t} = 0.00$   
   -Compression:  $A_{sl,c} = 3292.389$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $A_{sl,ten} = 983.3185$   
   -Compression:  $A_{sl,com} = 983.3185$   
   -Middle:  $A_{sl,mid} = 1325.752$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 177661.069$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 177661.069$   
 $V_{CoI} = 177661.069$   
 $k_n = 1.00$   
 displacement\_ductility\_demand = 0.00

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

= 1 (normal-weight concrete)  
 Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f_c'^{0.5} \leq 8.3$   
 MPa ((22.5.3.1, ACI 318-14))  
 $M/V_d = 2.00$   
 $M_u = 6.0481164E-008$   
 $V_u = 4.1944085E-011$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 218376.72$   
 $A_g = 40000.00$   
 From ((11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$   
 where:  
 $V_{s1} = 125663.706$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
 From ((11-11), ACI 440:  $V_s + V_f \leq 106288.613$   
 $bw = 200.00$



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  $\theta = 2.8425018E-018$

$y = (M_y * L_s / 3) / E_{eff} = 0.03854669$  ((4.29), Biskinis Phd))

$M_y = 1.0142E+008$

$L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3155E+012$

factor = 0.36543691

$A_g = 40000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 218376.72$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

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

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

$\phi_{y,ten} = 3.1090581E-005$

with  $f_y = 555.56$

$d = 172.00$

$y = 0.48055007$

$A = 0.10713558$

$B = 0.06707136$

with  $p_t = 0.02858484$

$p_c = 0.02858484$

$p_v = 0.03853931$

$N = 218376.72$

$b = 200.00$

$\alpha = 0.1627907$

$\phi_{y,comp} = 2.6245742E-005$

with  $f_c = 33.00$

$E_c = 26999.444$

$y = 0.48735376$

$A = 0.08128164$

$B = 0.05564476$

with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

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

At local axis: 3

Integration Section: (b)

## Calculation No. 8

column C1, Floor 1

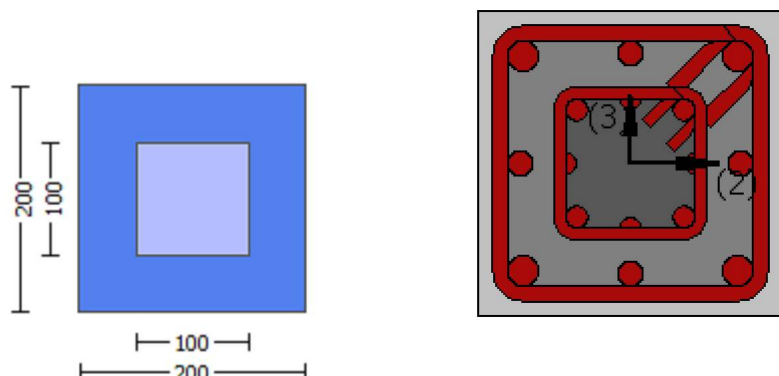
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity ( $\phi$ )

Edge: End

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{o,u,min} \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -8.1187678E-030$   
EDGE -B-  
Shear Force,  $V_b = 8.1187678E-030$   
BOTH EDGES  
Axial Force,  $F = -219397.073$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{l,com} = 983.3185$   
-Middle:  $As_{l,mid} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$   
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$   
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

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

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 3.2469244E-005$   
 $\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $\alpha = (5A.5, TBDY) = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \max(\mu_u, \mu_c) = 0.01053874$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.01053874$   
 $\mu_w (5.4c) = 0.03096488$   
 $\alpha_{se} ((5.4d), TBDY) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.16608997$   
 $\alpha_{se1} = 0.16608997$   
 $b_{o\_1} = 170.00$   
 $h_{o\_1} = 170.00$   
 $b_{i2\_1} = 115600.00$   
 $\alpha_{se2} = \max(\alpha_{se1}, \alpha_{se2}) = 0.16608997$

bo\_2 = 92.00  
ho\_2 = 92.00  
bi2\_2 = 33856.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 6.15233

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 200.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 100.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 200.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 100.00

Asec = 40000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293  
c = confinement factor = 1.06329

y1 = 0.0025  
sh1 = 0.008  
ft1 = 833.34  
fy1 = 694.45  
su1 = 0.032

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

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

y2 = 0.0025  
sh2 = 0.008  
ft2 = 833.34  
fy2 = 694.45  
su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

yv = 0.0025  
shv = 0.008

```

ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
    2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
    v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
    2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
    v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

```

--->

$$u = cu(4.2) = 3.2469244E-005$$

$$\mu = M_{Ro}$$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

Calculation of  $\mu_1$ -

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

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } cu = 0.01053874$$

$$w_e(5.4c) = 0.03096488$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$$

$$ase1 = 0.16608997$$

$$bo_1 = 170.00$$

$$ho_1 = 170.00$$

$$bi2_1 = 115600.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$

$$bo_2 = 92.00$$

$$ho_2 = 92.00$$

$$bi2_2 = 33856.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 100.00$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

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

$$h2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $y_1 = 0.0025$   
 $sh_1 = 0.008$   
 $ft_1 = 833.34$   
 $fy_1 = 694.45$   
 $su_1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/ld = 1.00$   
 $su_1 = 0.4 * esu_1, nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_1, nominal = 0.08$ ,  
 For calculation of  $esu_1, nominal$  and  $y_1, sh_1, ft_1, fy_1$ , it is considered  
 characteristic value  $fsy_1 = fs_1/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_1 = (fs, jacket * Asl, ten, jacket + fs, core * Asl, ten, core) / Asl, ten = 694.45$   
 with  $Es_1 = (Es, jacket * Asl, ten, jacket + Es, core * Asl, ten, core) / Asl, ten = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 833.34$   
 $fy_2 = 694.45$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/lb, min = 1.00$   
 $su_2 = 0.4 * esu_2, nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_2, nominal = 0.08$ ,  
 For calculation of  $esu_2, nominal$  and  $y_2, sh_2, ft_2, fy_2$ , it is considered  
 characteristic value  $fsy_2 = fs_2/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs_2 = (fs, jacket * Asl, com, jacket + fs, core * Asl, com, core) / Asl, com = 694.45$   
 with  $Es_2 = (Es, jacket * Asl, com, jacket + Es, core * Asl, com, core) / Asl, com = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $lo/lou, min = lb/ld = 1.00$   
 $suv = 0.4 * esuv, nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv, nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv, nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs, jacket * Asl, mid, jacket + fs, mid * Asl, mid, core) / Asl, mid = 694.45$   
 with  $Es_v = (Es, jacket * Asl, mid, jacket + Es, mid * Asl, mid, core) / Asl, mid = 200000.00$   
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.60153764$   
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.60153764$   
 $v = Asl, mid / (b * d) * (fsv / f_c) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.77530517$   
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.77530517$   
 $v = Asl, mid / (b * d) * (fsv / f_c) = 1.0453$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

```

---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

-----

Calculation of Mu2+

-----

-----

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

u = 3.2469244E-005

Mu = 1.3727E+008

-----

with full section properties:

```

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874

```



```

we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00

```

```

s1 = 100.00

```

```

s2 = 250.00

```

```

fywe1 = 694.45

```

```

fywe2 = 694.45

```

```

fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00263293

```

```

c = confinement factor = 1.06329

```

```

y1 = 0.0025

```

```

sh1 = 0.008

```

```

ft1 = 833.34

```

```

fy1 = 694.45

```

```

su1 = 0.032

```

```

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

```

```

lo/lou,min = lb/lb = 1.00

```

```

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

```

```

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

```

```

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

```

```

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

```

```

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

```

```

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

```

```

y2 = 0.0025

```

```

sh2 = 0.008

```

```

ft2 = 833.34

```

```

fy2 = 694.45

```

```

su2 = 0.032

```

```

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

```

```

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

```

```

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

```

```

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

```

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

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

with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

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

$y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$

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

$l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $suv = 0.4 \cdot es_{u\_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{u\_nominal} = 0.08$ , considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $es_{u\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.

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

with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.60153764$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.60153764$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.8110188$

and confined core properties:

$b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.77530517$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.77530517$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 1.0453$

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

--->

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

--->

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

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover  
 ' satisfies Eq. (4.4)

--->

$v < s_{y1}$  - LHS eq.(4.7) is not satisfied

--->

$v < v_{c,y1}$  - RHS eq.(4.6) is satisfied

--->

$cu (4.10) = 0.45915168$   
 $M_{Rc} (4.17) = 1.5179E+008$

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- $b$ ,  $d$ ,  $d'$  replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$
- $N_1$ ,  $N_2$ ,  $v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$
- parameters of confined concrete,  $f_{cc}$ ,  $cc$ , used in lieu of  $f_c$ ,  $ecu$

--->

Subcase: Rupture of tension steel

--->

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

--->

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

```

---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/ld
-----

Adequate Lap Length: lb/ld >= 1
-----

Calculation of Mu2-
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00
-----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

```

$$h2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5A5), \text{TB DY}), \text{TB DY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs1 / f_{ce}) = 0.60153764$$

$$2 = Asl, \text{com} / (b * d) * (fs2 / f_{ce}) = 0.60153764$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_{ce}) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TB DY}) = 35.08866$$

```

cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

-----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{Co1} \text{ ((10.3), ASCE 41-17)} = knl * V_{Co10}$

$V_{Co10} = 200506.935$

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$bw = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

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

$V_{Col0} = 200506.935$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$bw = 200.00$

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

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

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

#### Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -1.9686856E-030$

EDGE -B-

Shear Force,  $V_b = 1.9686856E-030$

BOTH EDGES

Axial Force,  $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{l,mid} = 1325.752$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.4563967$   
 Member Controlled by Flexure ( $V_e/V_r < 1$ )  
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
 with  
 $M_{pr1} = \text{Max}(Mu_{1+} , Mu_{1-}) = 1.3727E+008$   
 $Mu_{1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
 which is defined for the static loading combination  
 $Mu_{1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
 direction which is defined for the static loading combination  
 $M_{pr2} = \text{Max}(Mu_{2+} , Mu_{2-}) = 1.3727E+008$   
 $Mu_{2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
 which is defined for the the static loading combination  
 $Mu_{2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
 direction which is defined for the the static loading combination

Calculation of  $Mu_{1+}$

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

$$\phi_u = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$w_e (5.4c) = 0.03096488$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe} , p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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



No stirrups, ns\_2 = 2.00  
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 694.45

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

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.60153764

2 = Asl,com/(b\*d)\*(fs2/fc) = 0.60153764

v = Asl,mid/(b\*d)\*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00

d = 157.00

d' = 13.00

```

fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/ld
-----
Adequate Lap Length: lb/ld >= 1
-----

Calculation of Mu1-
-----

-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:
b = 200.00
d = 172.00

```

$d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $co(5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01053874$   
 $w_e(5.4c) = 0.03096488$   
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo_1 = 170.00$   
 $ho_1 = 170.00$   
 $bi2_1 = 115600.00$   
 $ase2 = Max(ase1, ase2) = 0.16608997$   
 $bo_2 = 92.00$   
 $ho_2 = 92.00$   
 $bi2_2 = 33856.00$   
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1(external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1(external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirups,  $ns_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirups,  $ns_2 = 2.00$   
 $h2 = 100.00$

$A_{sec} = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lo_{u,min} = lb/l_d = 1.00$

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

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

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

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

with  $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$

```

fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
    c = confinement factor = 1.06329
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
    2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
    v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

```

```

---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
Calculation of Mu2+
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00
-----

```

$psh\_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

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

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

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

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

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/lb = 1.00

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

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

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

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

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

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 694.45

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

```

1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

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

-----

Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----

-----

Calculation of Mu2-

-----

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

$$\phi_u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$$

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

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$\omega_e (5.4c) = 0.03096488$$

$$a_{se} ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

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

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

$$\text{Shear\_factor} = 1.00$$

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

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

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

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



characteristic value  $f_{sy1} = f_{s1}/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{s1} = (f_{sjacket} \cdot A_{sl,ten,jacket} + f_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 694.45$   
with  $E_{s1} = (E_{sjacket} \cdot A_{sl,ten,jacket} + E_{s,core} \cdot A_{sl,ten,core}) / A_{sl,ten} = 200000.00$   
 $y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $lo/lou, min = lb/lb, min = 1.00$   
 $su2 = 0.4 \cdot esu2\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
characteristic value  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{s2} = (f_{sjacket} \cdot A_{sl,com,jacket} + f_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 694.45$   
with  $E_{s2} = (E_{sjacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$   
 $yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$   
using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00  
 $lo/lou, min = lb/ld = 1.00$   
 $suv = 0.4 \cdot esuv\_nominal \cdot ((5.5), TBDY) = 0.032$   
From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY  
For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
with  $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 694.45$   
with  $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.60153764$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.60153764$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.8110188$   
and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = A_{sl,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.77530517$   
 $2 = A_{sl,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.77530517$   
 $v = A_{sl,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 1.0453$   
Case/Assumption: Unconfined full section - Steel rupture  
' satisfies Eq. (4.3)  
--->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied  
--->  
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied  
--->  
Case/Assumption Rejected.  
--->  
New Case/Assumption: Unconfined full section - Spalling of concrete cover  
' satisfies Eq. (4.4)  
--->  
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied  
--->  
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied  
--->  
 $cu (4.10) = 0.45915168$

MRC (4.17) = 1.5179E+008

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N,  $\epsilon_1$ ,  $\epsilon_2$ ,  $\nu$  normalised to bo\*do, instead of b\*d
- parameters of confined concrete, fcc,  $\epsilon_{cc}$ , used in lieu of fc,  $\epsilon_{cu}$

--->

Subcase: Rupture of tension steel

--->

$\nu^* < \nu^* s_y 2$  - LHS eq.(4.5) is not satisfied

--->

$\nu^* < \nu^* s_c$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$\nu^* < \nu^* c_y 2$  - LHS eq.(4.6) is satisfied

--->

\*cu (4.12) = 0.51649622

MRO (4.16) = 1.3727E+008

--->

$u = \epsilon_{cu}$  (4.2) = 3.2469244E-005

Mu = MRO

-----  
Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

-----  
Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

-----  
Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) = knl\*VCol0

VCol0 = 200506.935

knl = 1 (zero step-static loading)

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

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

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

M/Vd = 2.00

Mu = 2.0213315E-011

Vu = 1.9686856E-030

d = 0.8\*h = 160.00

Nu = 219397.073

Ag = 40000.00

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

d = 160.00

$A_v = 157079.633$

$f_y = 555.56$

s = 100.00

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

s/d = 0.625

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

d = 80.00

$A_v = 100530.965$

$f_y = 555.56$

s = 250.00

Vs2 is multiplied by Col2 = 0.00  
s/d = 3.125  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 122116.319  
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 200506.935  
Vr2 = VCol ((10.3), ASCE 41-17) = knl\*VCol0  
VCol0 = 200506.935  
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av\*fy\*d/s' is replaced by 'Vs+ f\*Vf'  
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
Mean concrete strength: fc' = (fc'\_jacket\*Area\_jacket + fc'\_core\*Area\_core)/Area\_section = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)  
M/Vd = 2.00  
Mu = 2.0213315E-011  
Vu = 1.9686856E-030  
d = 0.8\*h = 160.00  
Nu = 219397.073  
Ag = 40000.00  
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457  
where:  
Vs1 = 139627.457 is calculated for jacket, with:  
d = 160.00  
Av = 157079.633  
fy = 555.56  
s = 100.00  
Vs1 is multiplied by Col1 = 1.00  
s/d = 0.625  
Vs2 = 0.00 is calculated for core, with:  
d = 80.00  
Av = 100530.965  
fy = 555.56  
s = 250.00  
Vs2 is multiplied by Col2 = 0.00  
s/d = 3.125  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 122116.319  
bw = 200.00

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

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

Constant Properties

Knowledge Factor, = 1.00  
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00  
New material of Secondary Member: Steel Strength, fs = fsm = 555.56  
Concrete Elasticity, Ec = 26999.444  
Steel Elasticity, Es = 200000.00

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_b/l_d \geq 1$ )

No FRP Wrapping

Stepwise Properties

Bending Moment,  $M = -6.2875E+006$

Shear Force,  $V_2 = 31530.033$

Shear Force,  $V_3 = -4.1944085E-011$

Axial Force,  $F = -218376.72$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{mid} = 1325.752$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

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

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

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

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten,core} = 153.938$

-Compression:  $As_{c,com,core} = 153.938$

-Middle:  $As_{mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $Db_L = 17.50$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.0122049$

$u = y + p = 0.0122049$

- Calculation of  $y$  -

$y = (M_y * L_s / 3) / E_{eff} = 0.00770934$  ((4.29), Biskinis Phd))

$M_y = 1.0142E+008$

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

From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3155E+012$

factor = 0.36543691

$A_g = 40000.00$

Mean concrete strength:  $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$

$N = 218376.72$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

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

```

y = Min( y_ten, y_com)
y_ten = 3.1090581E-005
with fy = 555.56
d = 172.00
y = 0.48055007
A = 0.10713558
B = 0.06707136
with pt = 0.02858484
pc = 0.02858484
pv = 0.03853931
N = 218376.72
b = 200.00
" = 0.1627907
y_comp = 2.6245742E-005
with fc = 33.00
Ec = 26999.444
y = 0.48735376
A = 0.08128164
B = 0.05564476
with Es = 200000.00

```

Calculation of ratio  $l_b/d$

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

- Calculation of  $p$  -

From table 10-8:  $p = 0.00449557$

with:

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

shear control ratio  $V_yE/V_{col}E = 0.4563967$

$d = d_{external} = 172.00$

$s = s_{external} = 150.00$

$t = s_1 + s_2 + 2*tf/bw*(f_{fe}/f_s) = 0.00885929$

jacket:  $s_1 = A_{v1}*h_1/(s_1*Ag) = 0.00785398$

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

$h_1 = 200.00$

$s_1 = 100.00$

core:  $s_2 = A_{v2}*h_2/(s_2*Ag) = 0.00100531$

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

$h_2 = 100.00$

$s_2 = 250.00$

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.

$NUD = 218376.72$

$Ag = 40000.00$

$f_{cE} = (f_{c\_jacket}*Area\_jacket + f_{c\_core}*Area\_core)/section\_area = 33.00$

$f_{yE} = (f_{y\_ext\_Long\_Reinf}*Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf}*Area\_int\_Long\_Reinf)/Area\_Tot\_Long\_Rein =$

555.56

$f_{yE} = (f_{y\_ext\_Trans\_Reinf}*s_1 + f_{y\_int\_Trans\_Reinf}*s_2)/(s_1 + s_2) = 555.56$

$p_l = Area\_Tot\_Long\_Rein/(b*d) = 0.09570899$

$b = 200.00$

$d = 172.00$

$f_{cE} = 33.00$

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

At local axis: 3

Integration Section: (b)

## Calculation No. 9

column C1, Floor 1

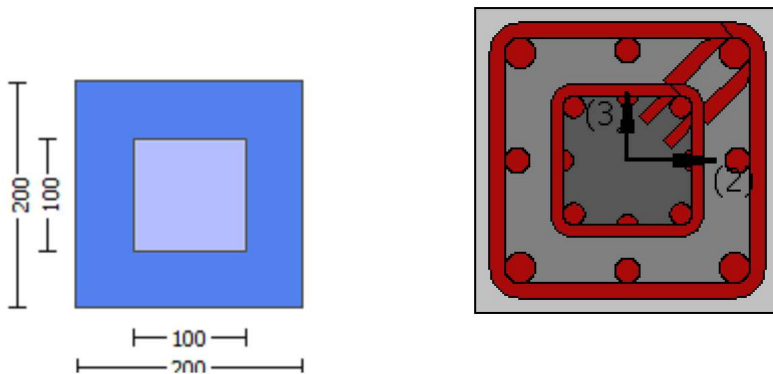
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

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

Jacket

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

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

Existing Column

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

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment,  $M_a = -1.3301E+008$

Shear Force,  $V_a = -37594.437$

EDGE -B-

Bending Moment,  $M_b = -7.4968E+006$

Shear Force,  $V_b = 37594.437$

BOTH EDGES

Axial Force,  $F = -218084.658$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 2001.195$

-Compression:  $As_c = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{mid} = 1325.752$

Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 141958.469$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{CoI} = 141958.469$

$V_{CoI} = 141958.469$

$k_n = 1.00$

displacement\_ductility\_demand = 0.46397517

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

where  $V_f$  is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa ((22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 1.3301E+008$

$V_u = 37594.437$

$d = 0.8 \cdot h = 160.00$

$N_u = 218084.658$

$A_g = 40000.00$

From ((11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 106288.613$   
 $b_w = 200.00$

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  $\theta = 0.04221101$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.09097686 ((4.29), Biskinis Phd)$   
 $M_y = 1.0143E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 3537.917  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3147E+012$   
 $factor = 0.36521565$   
 $A_g = 40000.00$   
 Mean concrete strength:  $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 218084.658$   
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

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

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 3.1087819E-005$   
 with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48050392$   
 $A = 0.1071203$   
 $B = 0.06705607$   
 with  $p_t = 0.02858484$   
 $p_c = 0.02858484$   
 $p_v = 0.03853931$   
 $N = 218084.658$   
 $b = 200.00$   
 $\rho = 0.1627907$   
 $y_{comp} = 2.6249185E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48728983$   
 $A = 0.08130094$   
 $B = 0.05564476$   
 with  $E_s = 200000.00$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1  
 At local axis: 2  
 Integration Section: (a)



## Calculation No. 10

column C1, Floor 1

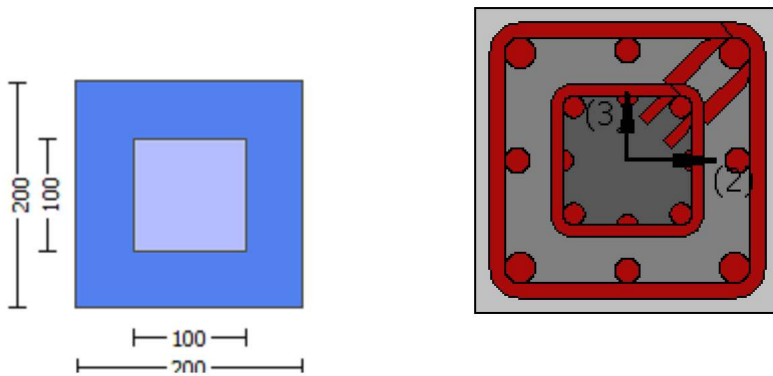
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Mean Confinement Factor overall section = 1.06329  
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

At local axis: 3  
EDGE -A-  
Shear Force,  $V_a = -8.1187678E-030$   
EDGE -B-  
Shear Force,  $V_b = 8.1187678E-030$   
BOTH EDGES  
Axial Force,  $F = -219397.073$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{c,com} = 983.3185$   
-Middle:  $As_{mid} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$   
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$   
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 1.3727E+008$ , 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:  
 $\phi_u = 3.2469244E-005$   
 $\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $\phi_c (5A.5, TBDY) = 0.002$

Final value of  $cu$ :  $cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01053874$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $cu = 0.01053874$   
we (5.4c) = 0.03096488  
ase ((5.4d), TBDY) =  $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo\_1 = 170.00$   
 $ho\_1 = 170.00$   
 $bi2\_1 = 115600.00$   
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$   
 $bo\_2 = 92.00$   
 $ho\_2 = 92.00$   
 $bi2\_2 = 33856.00$   
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1$  (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2$  (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1$  (external) =  $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2$  (internal) =  $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$A_{sec} = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

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

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

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

with  $fs1 = (fs, \text{jacket} * A_{sl, \text{ten, jacket}} + fs, \text{core} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 694.45$

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

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

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

```

lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->

```

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

--->

$*c_u$  (4.12) = 0.51649622

$M_{Ro}$  (4.16) = 1.3727E+008

--->

$u = c_u$  (4.2) = 3.2469244E-005

$\mu = M_{Ro}$

Calculation of ratio  $l_b/l_d$

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

Calculation of  $\mu_1$ -

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

$u = 3.2469244E-005$

$\mu = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

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

Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01053874$

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

From (5.4b), TBDY:  $c_u = 0.01053874$

$w_e$  (5.4c) = 0.03096488

$\alpha_e$  ((5.4d), TBDY) =  $(\alpha_e1 * A_{ext} + \alpha_e2 * A_{int}) / A_{sec} = 0.16608997$

$\alpha_e1 = 0.16608997$

$b_{o\_1} = 170.00$

$h_{o\_1} = 170.00$

$b_{i2\_1} = 115600.00$

$\alpha_e2 = \text{Max}(\alpha_e1, \alpha_e2) = 0.16608997$

$b_{o\_2} = 92.00$

$h_{o\_2} = 92.00$

$b_{i2\_2} = 33856.00$

$p_{sh,min} * F_{ywe} = \text{Min}(p_{sh,x} * F_{ywe}, p_{sh,y} * F_{ywe}) = 6.15233$

$p_{sh,x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

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

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

$h_1 = 200.00$

$p_{s2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

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

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

$h_2 = 100.00$

$p_{sh,y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$

$p_{s1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

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

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

$h_1 = 200.00$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$$

$$Ash2 = Astir\_2 \cdot ns\_2 = 100.531$$

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

$$h2 = 100.00$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.5), \text{TB DY}), \text{TB DY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs1 = (fs\_jacket \cdot Asl, \text{ten, jacket} + fs\_core \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

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

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

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

$$\text{with } fs2 = (fs\_jacket \cdot Asl, \text{com, jacket} + fs\_core \cdot Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

$$\text{considering characteristic value } fsyv = fsv/1.2, \text{ from table 5.1, TB DY}$$

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

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

$$\text{with } fsv = (fs\_jacket \cdot Asl, \text{mid, jacket} + fs\_mid \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

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

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.60153764$$

$$2 = Asl, \text{com} / (b \cdot d) \cdot (fs2 / fce) = 0.60153764$$

$$v = Asl, \text{mid} / (b \cdot d) \cdot (fsv / fce) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

```

d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----

Adequate Lap Length: lb/d >= 1
-----

Calculation of Mu2+
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:

```

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $fc = 33.00$   
 $co(5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01053874$   
 $w_e(5.4c) = 0.03096488$   
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo_1 = 170.00$   
 $ho_1 = 170.00$   
 $bi2_1 = 115600.00$   
 $ase2 = Max(ase1, ase2) = 0.16608997$   
 $bo_2 = 92.00$   
 $ho_2 = 92.00$   
 $bi2_2 = 33856.00$   
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1(external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1(external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir_1 * ns_1 = 157.0796$   
 No stirrups,  $ns_1 = 2.00$   
 $h1 = 200.00$   
 $ps2(internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir_2 * ns_2 = 100.531$   
 No stirrups,  $ns_2 = 2.00$   
 $h2 = 100.00$

$A_{sec} = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

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

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

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

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

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

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

with  $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 694.45$

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

$y2 = 0.0025$



```

sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o

```

```

- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----
Calculation of Mu2-
-----
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

```

$$h2 = 100.00$$

$$\begin{aligned} psh\_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.15233 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir\_1 * ns\_1 = 157.0796 \\ \text{No stirups, } ns\_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00100531 \\ Ash2 &= Astir\_2 * ns\_2 = 100.531 \\ \text{No stirups, } ns\_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

From table 5A.1, TB DY: 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, TB DY.

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

$$\text{with } fs1 = (fs\_jacket * Asl, \text{ten, jacket} + fs\_core * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

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

From table 5A.1, TB DY: 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, TB DY.

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

$$\text{with } fs2 = (fs\_jacket * Asl, \text{com, jacket} + fs\_core * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

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

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

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

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

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 = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/ld
-----
Adequate Lap Length: lb/ld >= 1
-----
-----
-----
-----
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 200506.935

```

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{col} \text{ ((10.3), ASCE 41-17)} = knl * V_{col0}$

$V_{col0} = 200506.935$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$bw = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

$V_{r2} = V_{col} \text{ ((10.3), ASCE 41-17)} = knl * V_{col0}$

$V_{col0} = 200506.935$

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

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

$= 1$  (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 3.125

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

From (11-11), ACI 440: Vs + Vf <= 122116.319

bw = 200.00

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

At local axis: 3

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

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

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

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

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

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

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

New material: Steel Strength, fs = 1.25\*fsm = 694.45

Existing Column

New material: Steel Strength, fs = 1.25\*fsm = 694.45

#####

External Height, H = 200.00

External Width, W = 200.00

Internal Height, H = 100.00

Internal Width, W = 100.00

Cover Thickness, c = 10.00

Mean Confinement Factor overall section = 1.06329

Element Length, L = 3000.00

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lo<sub>u</sub>, min >= 1)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, Va = -1.9686856E-030

EDGE -B-

Shear Force, Vb = 1.9686856E-030

BOTH EDGES

Axial Force,  $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{mid} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$

$Mu_{1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$

$Mu_{2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3727E+008$ , 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:

$\phi_u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

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

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$

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

From (5.4b), TBDY:  $\phi_u = 0.01053874$

we (5.4c)  $= 0.03096488$

ase ((5.4d), TBDY)  $= (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$

ase1  $= 0.16608997$

bo\_1  $= 170.00$

ho\_1  $= 170.00$

bi2\_1  $= 115600.00$

ase2  $= \text{Max}(ase1, ase2) = 0.16608997$

bo\_2  $= 92.00$

ho\_2  $= 92.00$

bi2\_2  $= 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$

ps1 (external)  $= (Ash1 * h1 / s1) / A_{sec} = 0.00785398$

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirups,  $ns_1 = 2.00$

$h1 = 200.00$

ps2 (internal)  $= (Ash2 * h2 / s2) / A_{sec} = 0.00100531$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, ns\_2 = 2.00  
h2 = 100.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 200.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY  
For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.



```

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$\nu = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$\phi_{0.5A,5,TBDY} = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$\phi_{0.5A,5,TBDY} = 0.03096488$$

$$\phi_{0.5A,5,TBDY} = (\phi_{0.5A,5,TBDY} * A_{ext} + \phi_{0.5A,5,TBDY} * A_{int}) / A_{sec} = 0.16608997$$

$$\phi_{0.5A,5,TBDY} = 0.16608997$$

$$b_{0,1} = 170.00$$

$$h_{0,1} = 170.00$$

$$b_{i2,1} = 115600.00$$

$$\phi_{0.5A,5,TBDY} = \text{Max}(\phi_{0.5A,5,TBDY}, \phi_{0.5A,5,TBDY}) = 0.16608997$$

$$b_{0,2} = 92.00$$

$$h_{0,2} = 92.00$$

$$b_{i2,2} = 33856.00$$

$$\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 6.15233$$

$$\phi_{psh,x} * F_{ywe} = \phi_{psh,1} * F_{ywe,1} + \phi_{psh,2} * F_{ywe,2} = 6.15233$$

$$\phi_{psh,1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirups, } n_{s,1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{psh,2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirups, } n_{s,2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{psh,y} * F_{ywe} = \phi_{psh,1} * F_{ywe,1} + \phi_{psh,2} * F_{ywe,2} = 6.15233$$

$$\phi_{psh,1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir,1} * n_{s,1} = 157.0796$$

$$\text{No stirups, } n_{s,1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{psh,2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir,2} * n_{s,2} = 100.531$$

$$\text{No stirups, } n_{s,2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe,1} = 694.45$$

$$f_{ywe,2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

$$l_o / l_{ou,min} = l_b / d = 1.00$$

```

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value 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 = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->

```

$v < v_{c,y1}$  - RHS eq.(4.6) is satisfied  
 ---->  
 $c_u(4.10) = 0.45915168$   
 $M_{Rc}(4.17) = 1.5179E+008$   
 ---->  
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover  
 In expressions below, the following modifications have been made  
 -  $b, d, d'$  replaced by geometric parameters of the core:  $b_o, d_o, d'_o$   
 -  $N, 1, 2, v$  normalised to  $b_o*d_o$ , instead of  $b*d$   
 - parameters of confined concrete,  $f_{cc}, \epsilon_{cc}$ , used in lieu of  $f_c, \epsilon_{cu}$   
 ---->  
 Subcase: Rupture of tension steel  
 ---->  
 $v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied  
 ---->  
 $v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied  
 ---->  
 Subcase rejected  
 ---->  
 New Subcase: Failure of compression zone  
 ---->  
 $v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied  
 ---->  
 $*c_u(4.12) = 0.51649622$   
 $M_{Ro}(4.16) = 1.3727E+008$   
 ---->  
 $u = c_u(4.2) = 3.2469244E-005$   
 $\mu = M_{Ro}$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

Calculation of  $\mu_{2+}$

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$u = 3.2469244E-005$   
 $\mu = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $\epsilon_{co}(5A.5, \text{TBDY}) = 0.002$   
 Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, \epsilon_{cc}) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $c_u = 0.01053874$   
 $w_e(5.4c) = 0.03096488$   
 $a_{se}((5.4d), \text{TBDY}) = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.16608997$   
 $a_{se1} = 0.16608997$   
 $b_{o\_1} = 170.00$   
 $h_{o\_1} = 170.00$   
 $b_{i2\_1} = 115600.00$   
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$   
 $b_{o\_2} = 92.00$   
 $h_{o\_2} = 92.00$   
 $b_{i2\_2} = 33856.00$   
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$

$psh\_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$A_{sec} = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$

$f_{ywe1} = 694.45$   
 $f_{ywe2} = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/ld = 1.00$

$su1 = 0.4 * esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$

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  $fs1 = (fs\_jacket * A_{sl, ten, jacket} + fs\_core * A_{sl, ten, core}) / A_{sl, ten} = 694.45$

with  $Es1 = (Es\_jacket * A_{sl, ten, jacket} + Es\_core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$   
 $lo/lou, min = lb/lb, min = 1.00$

$su2 = 0.4 * esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs\_jacket * A_{sl, com, jacket} + fs\_core * A_{sl, com, core}) / A_{sl, com} = 694.45$

with  $Es2 = (Es\_jacket * A_{sl, com, jacket} + Es\_core * A_{sl, com, core}) / A_{sl, com} = 200000.00$

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with

```

Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5, TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

```

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\mu_2$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 3.2469244E-005$$

$$\mu_u = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$\nu = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear\_factor} * \text{Max}(\mu_u, c_o) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_u = 0.01053874$$

$$\mu_{ue} \text{ (5.4c)} = 0.03096488$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

```

ft1 = 833.34
fy1 = 694.45
su1 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu1_nominal = 0.08,
    For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
    characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
    with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/lb,min = 1.00
    su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esu2_nominal = 0.08,
    For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
    characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
    with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lou,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->

```



Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover  
' satisfies Eq. (4.4)

---->

$v < s, y1$  - LHS eq.(4.7) is not satisfied

---->

$v < v_c, y1$  - RHS eq.(4.6) is satisfied

---->

$c_u$  (4.10) = 0.45915168

$M_{Rc}$  (4.17) = 1.5179E+008

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$
- $N_1$ ,  $N_2$ ,  $v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$
- $f_{cc}$ ,  $\epsilon_{cc}$  parameters of confined concrete,  $f_{cc}$ ,  $\epsilon_{cc}$  used in lieu of  $f_c$ ,  $\epsilon_{cu}$

---->

Subcase: Rupture of tension steel

---->

$v^* < v^* s, y2$  - LHS eq.(4.5) is not satisfied

---->

$v^* < v^* s, c$  - LHS eq.(4.5) is not satisfied

---->

Subcase rejected

---->

New Subcase: Failure of compression zone

---->

$v^* < v^* c, y2$  - LHS eq.(4.6) is satisfied

---->

$c_u$  (4.12) = 0.51649622

$M_{Ro}$  (4.16) = 1.3727E+008

---->

$u = c_u$  (4.2) = 3.2469244E-005

$\mu = M_{Ro}$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{Col}$  ((10.3), ASCE 41-17) =  $k_n l V_{Col0}$

$V_{Col0} = 200506.935$

$k_n l = 1$  (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:  $f'_c = (f'_c \text{ jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \text{ core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$V_u = 1.9686856E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.625$$

Vs2 = 0.00 is calculated for core, with:

$$d = 80.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 3.125$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$$b_w = 200.00$$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_n I V_{Col0}$

$$V_{Col0} = 200506.935$$

$k_n I = 1$  (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:  $f'_c = (f'_c \text{ jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \text{ core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$$M/Vd = 2.00$$

$$\mu_u = 2.0213315E-011$$

$$V_u = 1.9686856E-030$$

$$d = 0.8 \cdot h = 160.00$$

$$N_u = 219397.073$$

$$A_g = 40000.00$$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

Vs1 = 139627.457 is calculated for jacket, with:

$$d = 160.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

Vs1 is multiplied by Col1 = 1.00

$$s/d = 0.625$$

Vs2 = 0.00 is calculated for core, with:

$$d = 80.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 3.125$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$$b_w = 200.00$$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\phi = 1.00$   
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 External Height,  $H = 200.00$   
 External Width,  $W = 200.00$   
 Internal Height,  $H = 100.00$   
 Internal Width,  $W = 100.00$   
 Cover Thickness,  $c = 10.00$   
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_b/l_d \geq 1$ )  
 No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -9.9495397E-008$   
 Shear Force,  $V_2 = -37594.437$   
 Shear Force,  $V_3 = 6.2539570E-011$   
 Axial Force,  $F = -218084.658$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
   -Tension:  $As_t = 2001.195$   
   -Compression:  $As_c = 1291.195$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten} = 983.3185$   
   -Compression:  $As_{l,com} = 983.3185$   
   -Middle:  $As_{l,mid} = 1325.752$   
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,jacket} = 829.3805$   
   -Compression:  $As_{l,com,jacket} = 829.3805$   
   -Middle:  $As_{l,mid,jacket} = 402.1239$   
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)  
   -Tension:  $As_{t,ten,core} = 153.938$   
   -Compression:  $As_{l,com,core} = 153.938$   
   -Middle:  $As_{l,mid,core} = 923.6282$   
 Mean Diameter of Tension Reinforcement,  $Db_L = 17.50$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $\phi_{u,R} = 1.0^*$   $\phi_u = 0.07272853$   
 $\phi_u = \phi_y + \phi_p = 0.07272853$

- Calculation of  $\phi_y$  -

$\phi_y = (M_y * L_s / 3) / E_{eff} = 0.03857221$  ((4.29), Biskinis Phd))  
 $M_y = 1.0143E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3147E+012$   
 factor = 0.36521565

$$A_g = 40000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$$

$$N = 218084.658$$

$$E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 3.5999\text{E}+012$$

#### Calculation of Yielding Moment $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 3.1087819\text{E}-005$$

$$\text{with } f_y = 555.56$$

$$d = 172.00$$

$$y = 0.48050392$$

$$A = 0.1071203$$

$$B = 0.06705607$$

$$\text{with } p_t = 0.02858484$$

$$p_c = 0.02858484$$

$$p_v = 0.03853931$$

$$N = 218084.658$$

$$b = 200.00$$

$$" = 0.1627907$$

$$y_{\text{comp}} = 2.6249185\text{E}-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.48728983$$

$$A = 0.08130094$$

$$B = 0.05564476$$

$$\text{with } E_s = 200000.00$$

#### Calculation of ratio $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03415631$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $I_b/I_d \geq 1$

shear control ratio  $V_y E / V_{col} E = 0.4563967$

$$d = d_{\text{external}} = 172.00$$

$$s = s_{\text{external}} = 150.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00885929$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00785398$$

$A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 200.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00100531$$

$A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 100.00$$

$$s_2 = 250.00$$

The term  $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$  is implemented to account for FRP contribution

where  $f = 2 \cdot t_f / b_w$  is FRP ratio (EC8 - 3, A.4.4.3(6)) and  $f_{fe} / f_s$  normalises  $f$  to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation  $f_s$  of jacket is used.

$$N_{UD} = 218084.658$$

$$A_g = 40000.00$$

$$f_{cE} = (f_{c_{\text{jacket}}} \cdot \text{Area}_{\text{jacket}} + f_{c_{\text{core}}} \cdot \text{Area}_{\text{core}}) / \text{section\_area} = 33.00$$

$$f_{yE} = (f_{y_{\text{ext\_Long\_Reinf}}} \cdot \text{Area}_{\text{ext\_Long\_Reinf}} + f_{y_{\text{int\_Long\_Reinf}}} \cdot \text{Area}_{\text{int\_Long\_Reinf}}) / \text{Area}_{\text{Tot\_Long\_Rein}} = 555.56$$

$$f_{yE} = (f_{y_{\text{ext\_Trans\_Reinf}}} \cdot s_1 + f_{y_{\text{int\_Trans\_Reinf}}} \cdot s_2) / (s_1 + s_2) = 555.56$$

$$p_l = \text{Area}_{\text{Tot\_Long\_Rein}} / (b \cdot d) = 0.09570899$$

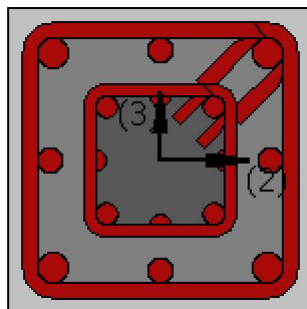
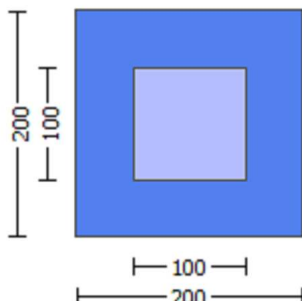
$$b = 200.00$$

d = 172.00  
f<sub>cE</sub> = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 2  
Integration Section: (a)

## Calculation No. 11

column C1, Floor 1  
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)  
Analysis: Uniform +X  
Check: Shear capacity VR<sub>d</sub>  
Edge: Start  
Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (a)  
Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$

Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of  $\gamma$  for displacement ductility demand,  
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as  
Deformation-Controlled Action (Table C7-1, ASCE 41-17).  
Jacket  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
Existing Column  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
#####  
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
Bending Moment,  $M_a = -9.9495397E-008$   
Shear Force,  $V_a = 6.2539570E-011$   
EDGE -B-  
Bending Moment,  $M_b = -9.0143946E-008$   
Shear Force,  $V_b = -6.2539570E-011$   
BOTH EDGES  
Axial Force,  $F = -218084.658$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 2001.195$   
-Compression:  $As_c = 1291.195$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{c,com} = 983.3185$   
-Middle:  $As_{l,mid} = 1325.752$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $VR = 1.0 \cdot V_n = 177628.325$   
 $V_n$  ((10.3), ASCE 41-17) =  $k_n l \cdot V_{CoIO} = 177628.325$   
 $V_{CoI} = 177628.325$   
 $k_n l = 1.00$   
displacement\_ductility\_demand = 0.00

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
Mean concrete strength:  $f'_c = (f'_c \cdot \text{jacket} \cdot \text{Area}_{\text{jacket}} + f'_c \cdot \text{core} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $M_u = 9.9495397E-008$   
 $V_u = 6.2539570E-011$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 218084.658$

$A_g = 40000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$   
 where:  
 $V_{s1} = 125663.706$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 500.00$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 500.00$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 106288.613$   
 $bw = 200.00$

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  $\theta = 3.1068144E-018$   
 $y = (M_y * L_s / 3) / E_{eff} = 0.03857221$  ((4.29), Biskinis Phd))  
 $M_y = 1.0143E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
 From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3147E+012$   
 $factor = 0.36521565$   
 $A_g = 40000.00$   
 Mean concrete strength:  $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 218084.658$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

Calculation of  $\phi_y$  and  $M_y$  according to Annex 7 -

$y = \min(\phi_{y,ten}, \phi_{y,com})$   
 $\phi_{y,ten} = 3.1087819E-005$   
 with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48050392$   
 $A = 0.1071203$   
 $B = 0.06705607$   
 with  $p_t = 0.02858484$   
 $p_c = 0.02858484$   
 $p_v = 0.03853931$   
 $N = 218084.658$   
 $b = 200.00$   
 $\rho = 0.1627907$   
 $\phi_{y,comp} = 2.6249185E-005$   
 with  $f_c = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48728983$   
 $A = 0.08130094$   
 $B = 0.05564476$   
 with  $E_s = 200000.00$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

## Calculation No. 12

column C1, Floor 1

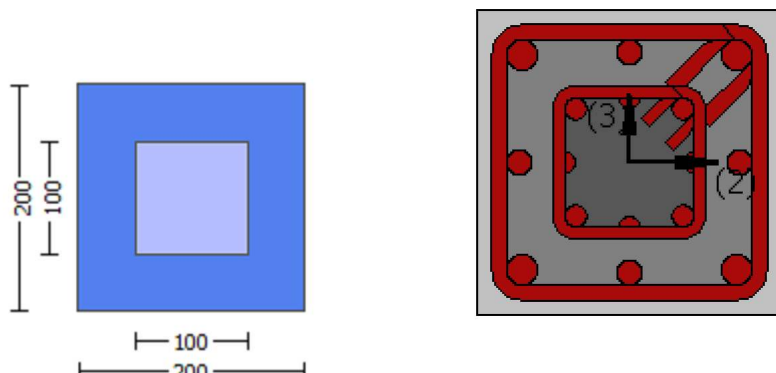
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\phi$  )

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$



#####

Note: Especially for the calculation of moment strengths,  
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )

No FRP Wrapping

-----  
Stepwise Properties

-----  
At local axis: 3

EDGE -A-

Shear Force,  $V_a = -8.1187678E-030$

EDGE -B-

Shear Force,  $V_b = 8.1187678E-030$

BOTH EDGES

Axial Force,  $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $A_{st} = 0.00$

-Compression:  $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $A_{st,ten} = 983.3185$

-Compression:  $A_{st,com} = 983.3185$

-Middle:  $A_{st,mid} = 1325.752$

-----  
Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.4563967$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \max(\mu_{1+}, \mu_{1-}) = 1.3727E+008$

$\mu_{1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction  
which is defined for the static loading combination

$\mu_{1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment  
direction which is defined for the static loading combination

$M_{pr2} = \max(\mu_{2+}, \mu_{2-}) = 1.3727E+008$

$\mu_{2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction  
which is defined for the the static loading combination

$\mu_{2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment  
direction which is defined for the the static loading combination

-----  
Calculation of  $\mu_{1+}$

-----  
Calculation of ultimate curvature  $\phi_u$  according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.2469244E-005$

$\mu_u = 1.3727E+008$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$\alpha (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \alpha: \alpha^* = \text{shear\_factor} * \text{Max}(\alpha, \alpha_c) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \alpha_c = 0.01053874$$

$$\alpha_{se} (5.4c) = 0.03096488$$

$$\alpha_{se} ((5.4d), \text{TB DY}) = (\alpha_{se1} * A_{ext} + \alpha_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$\alpha_{se1} = 0.16608997$$

$$b_{o1} = 170.00$$

$$h_{o1} = 170.00$$

$$b_{i21} = 115600.00$$

$$\alpha_{se2} = \text{Max}(\alpha_{se1}, \alpha_{se2}) = 0.16608997$$

$$b_{o2} = 92.00$$

$$h_{o2} = 92.00$$

$$b_{i22} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \alpha_c = 0.00263293$$

$$\alpha_c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$l_o / l_{o, \min} = l_b / l_d = 1.00$$

$$su_1 = 0.4 * esu_{1\_nominal} ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_{1\_nominal} = 0.08,$$

For calculation of  $esu_{1\_nominal}$  and  $y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , it is considered  
characteristic value  $fsy_1 = fs_1 / 1.2$ , from table 5.1, TB DY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (l_b / l_d)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{ten, jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 694.45$$

```

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

```

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo\*do, instead of b\*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

----

Subcase: Rupture of tension steel

----

$v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied

----

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

----

Subcase rejected

----

New Subcase: Failure of compression zone

----

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

----

\*cu (4.12) = 0.51649622

M<sub>Ro</sub> (4.16) = 1.3727E+008

----

u = cu (4.2) = 3.2469244E-005

Mu = M<sub>Ro</sub>

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

-----

Calculation of Mu1-

-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

-----

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01053874

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.16608997

ase1 = 0.16608997

bo\_1 = 170.00

ho\_1 = 170.00

bi2\_1 = 115600.00

ase2 = Max(ase1,ase2) = 0.16608997

bo\_2 = 92.00

ho\_2 = 92.00

bi2\_2 = 33856.00

psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 6.15233

-----

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233

ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398

Ash1 = Astir\_1\*ns\_1 = 157.0796

No stirups, ns\_1 = 2.00

h1 = 200.00

ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531

Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
 ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
 Ash1 = Astir\_1\*ns\_1 = 157.0796  
 No stirups, ns\_1 = 2.00  
 h1 = 200.00  
 ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
 Ash2 = Astir\_2\*ns\_2 = 100.531  
 No stirups, ns\_2 = 2.00  
 h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
 characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
 characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered

```

characteristic value  $f_{sv} = f_{sv}/1.2$ , from table 5.1, TBDY.
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.
with  $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$ 
with  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$ 
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.60153764$ 
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.60153764$ 
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.8110188$ 
and confined core properties:
 $b = 170.00$ 
 $d = 157.00$ 
 $d' = 13.00$ 
 $f_{cc} \text{ (5A.2, TBDY)} = 35.08866$ 
 $cc \text{ (5A.5, TBDY)} = 0.00263293$ 
 $c = \text{confinement factor} = 1.06329$ 
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.77530517$ 
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.77530517$ 
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 1.0453$ 
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied
--->
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
--->
 $v < s_{y1}$  - LHS eq.(4.7) is not satisfied
--->
 $v < v_{c,y1}$  - RHS eq.(4.6) is satisfied
--->
 $\phi_{cu} \text{ (4.10)} = 0.45915168$ 
 $M_{Rc} \text{ (4.17)} = 1.5179E+008$ 
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
-  $b, d, d'$  replaced by geometric parameters of the core:  $b_o, d_o, d'_o$ 
-  $N, 1, 2, v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$ 
- parameters of confined concrete,  $f_{cc}, cc$ , used in lieu of  $f_c, ec_u$ 
--->
Subcase: Rupture of tension steel
--->
 $v^* < v_{s,y2}$  - LHS eq.(4.5) is not satisfied
--->
 $v^* < v_{s,c}$  - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
 $v^* < v_{c,y2}$  - LHS eq.(4.6) is satisfied
--->
 $\phi_{cu} \text{ (4.12)} = 0.51649622$ 
 $M_{Ro} \text{ (4.16)} = 1.3727E+008$ 
--->
 $u = \phi_{cu} \text{ (4.2)} = 3.2469244E-005$ 
 $\mu = M_{Ro}$ 

```

-----

Calculation of ratio  $l_b/l_d$

-----

Adequate Lap Length:  $l_b/l_d \geq 1$

-----

-----

-----

## Calculation of $\mu_{2+}$

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, c_o) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.01053874$$

$$w_e(5.4c) = 0.03096488$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i2\_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i2\_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

and also multiplied by the shear\_factor according to 15.7.1.4, with

$$\text{Shear\_factor} = 1.00$$

```

lo/lou,min = lb/d = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/d = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied

```



```

---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:  
u = 3.2469244E-005  
Mu = 1.3727E+008

with full section properties:

```

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

$psh\_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$

$s1 = 100.00$

$s2 = 250.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A.5), TBDY), TBDY:  $cc = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou, \min = lb/ld = 1.00$

$su1 = 0.4 \cdot esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs\_jacket \cdot Asl, \text{ten}, \text{jacket} + fs\_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 694.45$

with  $Es1 = (Es\_jacket \cdot Asl, \text{ten}, \text{jacket} + Es\_core \cdot Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$lo/lou, \min = lb/lb, \min = 1.00$

$su2 = 0.4 \cdot esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

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  $fs2 = (fs\_jacket \cdot Asl, \text{com}, \text{jacket} + fs\_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 694.45$

with  $Es2 = (Es\_jacket \cdot Asl, \text{com}, \text{jacket} + Es\_core \cdot Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.34$

$fyv = 694.45$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor

```

and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Esjacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

```

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = k_n l V_{\text{ColO}}$

$V_{\text{ColO}} = 200506.935$

$k_n l = 1$  (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:  $f'_c = (f'_{c\_jacket} \text{Area}_{jacket} + f'_{c\_core} \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s2}$  is multiplied by  $\text{Col2} = 0.00$

$s/d = 3.125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

$V_{r2} = V_{\text{Col}} \text{ ((10.3), ASCE 41-17)} = k_n l V_{\text{ColO}}$

$V_{\text{ColO}} = 200506.935$

$k_n l = 1$  (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:  $f'_c = (f'_{c\_jacket} \text{Area}_{jacket} + f'_{c\_core} \text{Area}_{core}) / \text{Area}_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

Vs1 = 139627.457 is calculated for jacket, with:

d = 160.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.625

Vs2 = 0.00 is calculated for core, with:

d = 80.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 3.125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 122116.319

bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25\*fsm = 694.45

Existing Column

New material: Steel Strength, fs = 1.25\*fsm = 694.45

#####

External Height, H = 200.00

External Width, W = 200.00

Internal Height, H = 100.00

Internal Width, W = 100.00

Cover Thickness, c = 10.00

Mean Confinement Factor overall section = 1.06329

Element Length, L = 3000.00

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/lou,min>=1)

No FRP Wrapping

## Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force,  $V_a = -1.9686856E-030$

EDGE -B-

Shear Force,  $V_b = 1.9686856E-030$

BOTH EDGES

Axial Force,  $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 0.00$

-Compression:  $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{l,mid} = 1325.752$

Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.4563967$

Member Controlled by Flexure ( $V_e/V_r < 1$ )

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$

$Mu_{1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$

$Mu_{2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{2-} = 1.3727E+008$ , 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:

$\phi_u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

$\phi_c$  (5A.5, TBDY) = 0.002

Final value of  $\phi_u$ :  $\phi_u^* = \text{shear\_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\phi_u = 0.01053874$

$\phi_{we}$  (5.4c) = 0.03096488

$a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$

$a_{se1} = 0.16608997$

$bo\_1 = 170.00$

$ho\_1 = 170.00$

$bi2\_1 = 115600.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$

$bo\_2 = 92.00$

$ho\_2 = 92.00$

$bi2\_2 = 33856.00$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe , psh,y*Fywe) = 6.15233$$

$$psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$psh_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4*esu1\_nominal ((5.5), \text{ TBDY}) = 0.032$$

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.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25*(lb/l_d)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou,min = lb/l_b,min = 1.00$$

$$su2 = 0.4*esu2\_nominal ((5.5), \text{ TBDY}) = 0.032$$

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

$$y1, sh1,ft1,fy1, \text{ are also multiplied by } \text{Min}(1, 1.25*(lb/l_d)^{2/3}), \text{ from } 10.3.5, \text{ ASCE } 41-17.$$

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

```

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lo,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```



Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

Calculation of  $\mu_1$ -

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$\alpha (5A.5, \text{TB DY}) = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, \mu_c) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu = 0.01053874$$

$$\mu_e (5.4c) = 0.03096488$$

$$\alpha_e ((5.4d), \text{TB DY}) = (\alpha_1 * A_{ext} + \alpha_2 * A_{int}) / A_{sec} = 0.16608997$$

$$\alpha_1 = 0.16608997$$

$$b_{o\_1} = 170.00$$

$$h_{o\_1} = 170.00$$

$$b_{i\_1} = 115600.00$$

$$\alpha_2 = \text{Max}(\alpha_1, \alpha_2) = 0.16608997$$

$$b_{o\_2} = 92.00$$

$$h_{o\_2} = 92.00$$

$$b_{i\_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$$

$$\text{No stirups, } n_{s\_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$$

$$\text{No stirups, } n_{s\_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

```

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu1_nominal = 0.08,
For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45
with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00
y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->

```

```

v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----
Calculation of Mu2+
-----
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----
with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997

```

```

bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

From ((5.A5), TBDY), TBDY: cc = 0.00263293  
c = confinement factor = 1.06329

```

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

```

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

```

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

```

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < sy1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*sy2 - LHS eq.(4.5) is not satisfied
--->
v* < v*sc - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->

```

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

---->

$$*cu(4.12) = 0.51649622$$

$$MRo(4.16) = 1.3727E+008$$

---->

$$u = cu(4.2) = 3.2469244E-005$$

$$Mu = MRo$$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

Calculation of  $Mu_2$ -

Calculation of ultimate curvature  $u$  according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$co(5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear\_factor} * \text{Max}(cu, cc) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01053874$$

$$w_e(5.4c) = 0.03096488$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$$

$$ase1 = 0.16608997$$

$$bo_1 = 170.00$$

$$ho_1 = 170.00$$

$$bi2_1 = 115600.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$

$$bo_2 = 92.00$$

$$ho_2 = 92.00$$

$$bi2_2 = 33856.00$$

$$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$$

$$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$A_{sec} = 40000.00$$

$s1 = 100.00$   
 $s2 = 250.00$   
 $fy_{we1} = 694.45$   
 $fy_{we2} = 694.45$   
 $f_{ce} = 33.00$   
 From ((5.A.5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs_{jacket} * Asl, \text{ten}, \text{jacket} + fs_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 694.45$   
 with  $Es1 = (Es_{jacket} * Asl, \text{ten}, \text{jacket} + Es_{core} * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$   
 $y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs_{jacket} * Asl, \text{com}, \text{jacket} + fs_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 694.45$   
 with  $Es2 = (Es_{jacket} * Asl, \text{com}, \text{jacket} + Es_{core} * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$   
 $yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * Asl, \text{mid}, \text{jacket} + fs_{mid} * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 694.45$   
 with  $Es_v = (Es_{jacket} * Asl, \text{mid}, \text{jacket} + Es_{mid} * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / f_c) = 0.60153764$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / f_c) = 0.60153764$   
 $v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / f_c) = 0.77530517$

```

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

-----

-----

Calculation of Shear Strength  $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

-----

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = knl * V_{Col0}$

$V_{Col0} = 200506.935$

$knl = 1$  (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:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $fc'^{0.5} \leq 8.3$   
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$



$\mu_u = 2.0213315E-011$   
 $V_u = 1.9686856E-030$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
 where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$   
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_n l \cdot V_{Col0}$   
 $V_{Col0} = 200506.935$   
 $k_n l = 1$  (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:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0213315E-011$   
 $V_u = 1.9686856E-030$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
 From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
 where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by  $Col1 = 1.00$   
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by  $Col2 = 0.00$   
 $s/d = 3.125$   
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$   
 From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $b_w = 200.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
 At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$

Element Length,  $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ( $l_b/d \geq 1$ )

No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -1.3301E+008$

Shear Force,  $V_2 = -37594.437$

Shear Force,  $V_3 = 6.2539570E-011$

Axial Force,  $F = -218084.658$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension:  $As_t = 2001.195$

-Compression:  $As_c = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten} = 983.3185$

-Compression:  $As_{c,com} = 983.3185$

-Middle:  $As_{mid} = 1325.752$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten,jacket} = 829.3805$

-Compression:  $As_{c,com,jacket} = 829.3805$

-Middle:  $As_{mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $As_{t,ten,core} = 153.938$

-Compression:  $As_{c,com,core} = 153.938$

-Middle:  $As_{mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $Db_L = 17.50$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.12513318$

$u = \gamma + \rho = 0.12513318$

- Calculation of  $y$  -

$$y = (M_y * L_s / 3) / E_{eff} = 0.09097686 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.0143E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3537.917$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.3147E+012$$

$$\text{factor} = 0.36521565$$

$$A_g = 40000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 218084.658$$

$$E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 3.5999E+012$$

Calculation of Yielding Moment  $M_y$

Calculation of  $y$  and  $M_y$  according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 3.1087819E-005$$

$$\text{with } f_y = 555.56$$

$$d = 172.00$$

$$y = 0.48050392$$

$$A = 0.1071203$$

$$B = 0.06705607$$

$$\text{with } p_t = 0.02858484$$

$$p_c = 0.02858484$$

$$p_v = 0.03853931$$

$$N = 218084.658$$

$$b = 200.00$$

$$" = 0.1627907$$

$$y_{\text{comp}} = 2.6249185E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.48728983$$

$$A = 0.08130094$$

$$B = 0.05564476$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio  $I_b/I_d$

Adequate Lap Length:  $I_b/I_d \geq 1$

- Calculation of  $p$  -

$$\text{From table 10-8: } p = 0.03415631$$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $I_b/I_d \geq 1$

$$\text{shear control ratio } V_y E / V_{col} E = 0.4563967$$

$$d = d_{\text{external}} = 172.00$$

$$s = s_{\text{external}} = 150.00$$

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00885929$$

$$\text{jacket: } s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00785398$$

$$A_{v1} = 157.0796, \text{ is the total area of all stirrups parallel to loading (shear) direction}$$

$$h_1 = 200.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00100531$$

$$A_{v2} = 100.531, \text{ is the total area of all stirrups parallel to loading (shear) direction}$$

$$h_2 = 100.00$$

$$s_2 = 250.00$$

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 fs of jacket is used.

$$NUD = 218084.658$$

$$Ag = 40000.00$$

$$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 33.00$$

$$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 555.56$$

$$f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$$

$$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.09570899$$

$$b = 200.00$$

$$d = 172.00$$

$$f_{cE} = 33.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

## Calculation No. 13

column C1, Floor 1

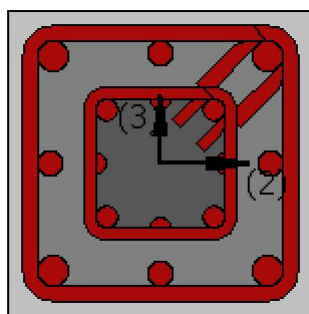
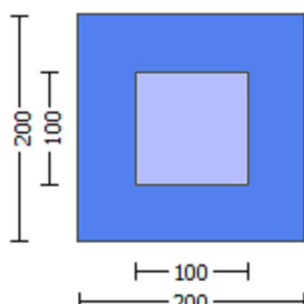
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
 Consequently:  
 Jacket  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 Existing Column  
 New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
 New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
 Concrete Elasticity,  $E_c = 26999.444$   
 Steel Elasticity,  $E_s = 200000.00$   
 #####  
 Note: Especially for the calculation of  $\gamma$  for displacement ductility demand,  
 the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as  
 Deformation-Controlled Action (Table C7-1, ASCE 41-17).  
 Jacket  
 New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
 Existing Column  
 New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
 New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
 #####  
 External Height,  $H = 200.00$   
 External Width,  $W = 200.00$   
 Internal Height,  $H = 100.00$   
 Internal Width,  $W = 100.00$   
 Cover Thickness,  $c = 10.00$   
 Element Length,  $L = 3000.00$   
 Secondary Member  
 Smooth Bars  
 Ductile Steel  
 With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
 Longitudinal Bars With Ends Lapped Starting at the End Sections  
 Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )  
 No FRP Wrapping

#### Stepwise Properties

EDGE -A-  
 Bending Moment,  $M_a = -1.3301E+008$   
 Shear Force,  $V_a = -37594.437$   
 EDGE -B-  
 Bending Moment,  $M_b = -7.4968E+006$   
 Shear Force,  $V_b = 37594.437$   
 BOTH EDGES  
 Axial Force,  $F = -218084.658$   
 Longitudinal Reinforcement Area Distribution (in 2 divisions)  
 -Tension:  $A_{st} = 0.00$   
 -Compression:  $A_{sc} = 3292.389$   
 Longitudinal Reinforcement Area Distribution (in 3 divisions)  
 -Tension:  $A_{st,ten} = 983.3185$   
 -Compression:  $A_{st,com} = 983.3185$   
 -Middle:  $A_{st,mid} = 1325.752$   
 Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$   
 -----  
 -----  
 New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 175388.999$   
 $V_n ((10.3), ASCE 41-17) = k_n \cdot V_{CoI} = 175388.999$   
 $V_{CoI} = 177628.325$   
 $k_n = 0.98739319$   
 $displacement\_ductility\_demand = 2.16809$   
 -----  
 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:  $f'_c = (f'_{c\_jacket} \cdot Area_{jacket} + f'_{c\_core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 7.4968E+006$

$V_u = 37594.437$

$d = 0.8 \cdot h = 160.00$

$N_u = 218084.658$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s1}$  is multiplied by  $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

$V_{s2}$  is multiplied by  $\text{Col2} = 0.00$

$s/d = 3.125$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 106288.613$

$b_w = 200.00$

displacement ductility demand is calculated as  $\delta_u / y$

- Calculation of  $\delta_u / y$  for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation  $\theta_r = 0.01672561$

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00771444$  ((4.29), Biskinis Phd))

$M_y = 1.0143E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 300.00

From table 10.5, ASCE 41\_17:  $E_{eff} = \text{factor} \cdot E_c \cdot I_g = 1.3147E+012$

$\text{factor} = 0.36521565$

$A_g = 40000.00$

Mean concrete strength:  $f'_c = (f'_{c\_jacket} \cdot Area_{jacket} + f'_{c\_core} \cdot Area_{core}) / Area_{section} = 33.00$

$N = 218084.658$

$E_c \cdot I_g = E_{c\_jacket} \cdot I_{g\_jacket} + E_{c\_core} \cdot I_{g\_core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

Calculation of  $\delta_u$  and  $M_y$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 3.1087819E-005$

with  $f_y = 555.56$

$d = 172.00$

$y = 0.48050392$

$A = 0.1071203$

$B = 0.06705607$

with  $pt = 0.02858484$

$pc = 0.02858484$

$pv = 0.03853931$

$N = 218084.658$

$b = 200.00$

" = 0.1627907  
y\_comp = 2.6249185E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.48728983  
A = 0.08130094  
B = 0.05564476  
with Es = 200000.00

-----

Calculation of ratio lb/l<sub>d</sub>

-----

Adequate Lap Length: lb/l<sub>d</sub> >= 1

-----

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

-----

## Calculation No. 14

column C1, Floor 1

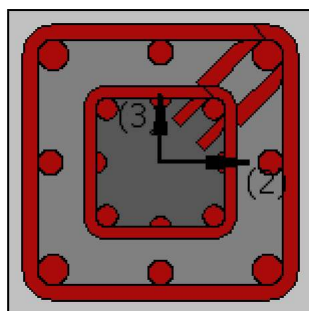
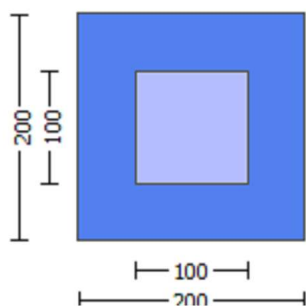
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (  $\mu$  )

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

-----

Knowledge Factor,  $\gamma$  = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

```

Jacket
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
External Height,  $H = 200.00$ 
External Width,  $W = 200.00$ 
Internal Height,  $H = 100.00$ 
Internal Width,  $W = 100.00$ 
Cover Thickness,  $c = 10.00$ 
Mean Confinement Factor overall section = 1.06329
Element Length,  $L = 3000.00$ 
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou}, \min >= 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -8.1187678E-030$ 
EDGE -B-
Shear Force,  $V_b = 8.1187678E-030$ 
BOTH EDGES
Axial Force,  $F = -219397.073$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{sl,t} = 0.00$ 
-Compression:  $A_{sl,c} = 3292.389$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{sl,ten} = 983.3185$ 
-Compression:  $A_{sl,com} = 983.3185$ 
-Middle:  $A_{sl,mid} = 1325.752$ 
-----
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$ 
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$ 
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$ 
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment

```



direction which is defined for the the static loading combination

Calculation of Mu1+

Calculation of ultimate curvature  $\mu$  according to 4.1, Biskinis/Fardis 2013:

$$\mu = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$cc \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear\_factor} * \text{Max}(\mu, cc) = 0.01053874$$

The Shear\_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu = 0.01053874$$

$$\mu_e \text{ (5.4c)} = 0.03096488$$

$$ase \text{ ((5.4d), TBDY)} = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$$

$$ase1 = 0.16608997$$

$$bo\_1 = 170.00$$

$$ho\_1 = 170.00$$

$$bi2\_1 = 115600.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$

$$bo\_2 = 92.00$$

$$ho\_2 = 92.00$$

$$bi2\_2 = 33856.00$$

$$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$$

$$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir\_1 * ns\_1 = 157.0796$$

$$\text{No stirups, } ns\_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir\_2 * ns\_2 = 100.531$$

$$\text{No stirups, } ns\_2 = 2.00$$

$$h2 = 100.00$$

$$psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$$

$$ps1 \text{ (external)} = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir\_1 * ns\_1 = 157.0796$$

$$\text{No stirups, } ns\_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir\_2 * ns\_2 = 100.531$$

$$\text{No stirups, } ns\_2 = 2.00$$

$$h2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fy_{we1} = 694.45$$

$$fy_{we2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $su_1 = 0.4 * esu_{1,nominal} ((5.5), TBDY) = 0.032$   
 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  $fs_1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$   
 with  $Es_1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$   
 $y_2 = 0.0025$   
 $sh_2 = 0.008$   
 $ft_2 = 833.34$   
 $fy_2 = 694.45$   
 $su_2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$   
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu_{2,nominal} = 0.08$ ,  
 For calculation of  $esu_{2,nominal}$  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  $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$   
 with  $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$   
 $y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 Shear\_factor = 1.00  
 $l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv_{nominal} = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv_{nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y_1, sh_1, ft_1, fy_1$ , are also multiplied by  $Min(1, 1.25 * (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$   
 with  $Esv = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.60153764$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.60153764$   
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.77530517$   
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.77530517$   
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 1.0453$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)  
 --->  
 $v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied  
 --->  
 $v < v_{s,c}$  - RHS eq.(4.5) is not satisfied  
 --->  
 Case/Assumption Rejected.  
 --->  
 New Case/Assumption: Unconfined full section - Spalling of concrete cover

```

satisfies Eq. (4.4)
---->
v < sy1 - LHS eq.(4.7) is not satisfied
---->
v < vcy1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N1, N2, v normalised to bo*do, instead of b*d
- fcc, fcc used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*sy2 - LHS eq.(4.5) is not satisfied
---->
v* < v*sc - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*cy2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

Calculation of ratio l<sub>b</sub>/l<sub>d</sub>

Adequate Lap Length: l<sub>b</sub>/l<sub>d</sub> >= 1

Calculation of Mu<sub>1</sub>-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005  
Mu = 1.3727E+008

with full section properties:

```

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00

```

$ho\_2 = 92.00$   
 $bi\_2 = 33856.00$   
 $psh,min*Fywe = \text{Min}(psh,x*Fywe, psh,y*Fywe) = 6.15233$

$psh\_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$   
 $Ash2 = Astir\_2*ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$psh\_y*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233$   
 $ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$   
 $Ash1 = Astir\_1*ns\_1 = 157.0796$   
 $\text{No stirups, } ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$   
 $Ash2 = Astir\_2*ns\_2 = 100.531$   
 $\text{No stirups, } ns\_2 = 2.00$   
 $h2 = 100.00$

$Asec = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $fce = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou,min = lb/ld = 1.00$

$su1 = 0.4*esu1\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$

with  $Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$

$lo/lou,min = lb/lb,min = 1.00$

$su2 = 0.4*esu2\_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,

For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25*(lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45$

with  $Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$

$yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$

```

fyv = 694.45
suv = 0.032
    using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
    and also multiplied by the shear_factor according to 15.7.1.4, with
    Shear_factor = 1.00
    lo/lo,min = lb/ld = 1.00
    suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
    From table 5A.1, TBDY: esuv_nominal = 0.08,
    considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
    For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
    characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
    y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
    with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
    with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
    2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
    v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
    c = confinement factor = 1.06329
    1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
    2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
    v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
    cu (4.10) = 0.45915168
    MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
    *cu (4.12) = 0.51649622
    MRo (4.16) = 1.3727E+008
---->

```

u = cu (4.2) = 3.2469244E-005  
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005  
Mu = 1.3727E+008

with full section properties:

b = 200.00  
d = 172.00  
d' = 28.00  
v = 0.19326733  
N = 219397.073  
fc = 33.00  
co (5A.5, TBDY) = 0.002  
Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01053874  
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY: cu = 0.01053874  
we (5.4c) = 0.03096488  
ase ((5.4d), TBDY) = (ase1\*Aext+ase2\*Aint)/Asec = 0.16608997  
ase1 = 0.16608997  
bo\_1 = 170.00  
ho\_1 = 170.00  
bi2\_1 = 115600.00  
ase2 = Max(ase1,ase2) = 0.16608997  
bo\_2 = 92.00  
ho\_2 = 92.00  
bi2\_2 = 33856.00  
psh,min\*Fywe = Min(psh,x\*Fywe , psh,y\*Fywe) = 6.15233

psh\_x\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 200.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 100.00

psh\_y\*Fywe = psh1\*Fywe1+ps2\*Fywe2 = 6.15233  
ps1 (external) = (Ash1\*h1/s1)/Asec = 0.00785398  
Ash1 = Astir\_1\*ns\_1 = 157.0796  
No stirups, ns\_1 = 2.00  
h1 = 200.00  
ps2 (internal) = (Ash2\*h2/s2)/Asec = 0.00100531  
Ash2 = Astir\_2\*ns\_2 = 100.531  
No stirups, ns\_2 = 2.00  
h2 = 100.00

Asec = 40000.00  
s1 = 100.00  
s2 = 250.00  
fywe1 = 694.45  
fywe2 = 694.45  
fce = 33.00

From ((5A.5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,  
 For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs1 = (fs\_jacket * Asl, \text{ten}, \text{jacket} + fs\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 694.45$   
 with  $Es1 = (Es\_jacket * Asl, \text{ten}, \text{jacket} + Es\_core * Asl, \text{ten}, \text{core}) / Asl, \text{ten} = 200000.00$   
 $y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$   
 $su2 = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/lb, \min = 1.00$   
 $su2 = 0.4 * esu2\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esu2\_nominal = 0.08$ ,  
 For calculation of  $esu2\_nominal$  and  $y2, sh2, ft2, fy2$ , it is considered  
 characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fs2 = (fs\_jacket * Asl, \text{com}, \text{jacket} + fs\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 694.45$   
 with  $Es2 = (Es\_jacket * Asl, \text{com}, \text{jacket} + Es\_core * Asl, \text{com}, \text{core}) / Asl, \text{com} = 200000.00$   
 $yv = 0.0025$   
 $shv = 0.008$   
 $ftv = 833.34$   
 $fyv = 694.45$   
 $suv = 0.032$   
 using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $\text{Shear\_factor} = 1.00$   
 $lo/lou, \min = lb/ld = 1.00$   
 $suv = 0.4 * esuv\_nominal ((5.5), TBDY) = 0.032$   
 From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,  
 considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY  
 For calculation of  $esuv\_nominal$  and  $yv, shv, ftv, fyv$ , it is considered  
 characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TBDY.  
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.  
 with  $fsv = (fs\_jacket * Asl, \text{mid}, \text{jacket} + fs\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 694.45$   
 with  $Es_v = (Es\_jacket * Asl, \text{mid}, \text{jacket} + Es\_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.60153764$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.60153764$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.8110188$   
 and confined core properties:  
 $b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $fcc (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.77530517$   
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.77530517$   
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 1.0453$   
 Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

---

```

v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
---->
v < vs,y1 - LHS eq.(4.7) is not satisfied
---->
v < vs,c - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v* < vs,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < vs,c - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

-----

Calculation of ratio lb/d

-----

Adequate Lap Length: lb/d >= 1

-----

-----

Calculation of Mu2-

-----

-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

-----

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu\* = shear\_factor \* Max( cu, cc) = 0.01053874

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488



```

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

```

```

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

```

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25\*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

```

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

```

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered

```

characteristic value  $fsy2 = fs2/1.2$ , from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.
with  $fs2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$ 
with  $Es2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$ 
 $yv = 0.0025$ 
 $shv = 0.008$ 
 $ftv = 833.34$ 
 $fyv = 694.45$ 
 $suv = 0.032$ 
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $lo/lou, min = lb/ld = 1.00$ 
 $suv = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$ 
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  $fsv = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$ 
with  $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$ 
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.60153764$ 
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.60153764$ 
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.8110188$ 
and confined core properties:
 $b = 170.00$ 
 $d = 157.00$ 
 $d' = 13.00$ 
 $fcc (5A.2, TBDY) = 35.08866$ 
 $cc (5A.5, TBDY) = 0.00263293$ 
 $c = \text{confinement factor} = 1.06329$ 
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.77530517$ 
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.77530517$ 
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 1.0453$ 
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
 $v < vs,y2$  - LHS eq.(4.5) is not satisfied
---->
 $v < vs,c$  - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
 $v < s,y1$  - LHS eq.(4.7) is not satisfied
---->
 $v < vc,y1$  - RHS eq.(4.6) is satisfied
---->
 $cu (4.10) = 0.45915168$ 
 $MRC (4.17) = 1.5179E+008$ 
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
-  $b, d, d'$  replaced by geometric parameters of the core:  $bo, do, d'o$ 
-  $N, 1, 2, v$  normalised to  $bo \cdot do$ , instead of  $b \cdot d$ 
-  $parameters of confined concrete, fcc, cc, used in lieu of fc, ecu$ 
---->
Subcase: Rupture of tension steel
---->
 $v^* < v^*,y2$  - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*,c$  - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->

```

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

--->

$*c_u (4.12) = 0.51649622$

$M_{Ro} (4.16) = 1.3727E+008$

--->

$u = c_u (4.2) = 3.2469244E-005$

$\mu = M_{Ro}$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of Shear Strength  $V_r = \min(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1,  $V_{r1} = 200506.935$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 200506.935$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f'_c = (f'_c_{jacket} * Area_{jacket} + f'_c_{core} * Area_{core}) / Area_{section} = 33.00$ , but  $f'_c^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\mu_v = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 0.00$

$s/d = 3.125$

$V_f ((11-3)-(11.4), ACI 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{Col0}$

$V_{Col0} = 200506.935$

$k_{nl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

$= 1$  (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

$V_{s1}$  is multiplied by  $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

$V_{s2}$  is multiplied by  $\text{Col2} = 0.00$

$s/d = 3.125$

$V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$

From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$

$b_w = 200.00$

-----

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

-----

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties

-----

Knowledge Factor,  $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$

Concrete Elasticity,  $E_c = 26999.444$

Steel Elasticity,  $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height,  $H = 200.00$

External Width,  $W = 200.00$

Internal Height,  $H = 100.00$

Internal Width,  $W = 100.00$

Cover Thickness,  $c = 10.00$   
Mean Confinement Factor overall section = 1.06329  
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou}, \min \geq 1$ )  
No FRP Wrapping

#### Stepwise Properties

At local axis: 2  
EDGE -A-  
Shear Force,  $V_a = -1.9686856E-030$   
EDGE -B-  
Shear Force,  $V_b = 1.9686856E-030$   
BOTH EDGES  
Axial Force,  $F = -219397.073$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{c,com} = 983.3185$   
-Middle:  $As_{mid} = 1325.752$

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$   
Member Controlled by Flexure ( $V_e/V_r < 1$ )  
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$   
with  
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$   
 $\mu_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination  
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$   
 $\mu_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination  
 $\mu_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

#### Calculation of $\mu_{u1+}$

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:  
 $\mu_u = 3.2469244E-005$   
 $\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$   
 $d = 172.00$   
 $d' = 28.00$   
 $v = 0.19326733$   
 $N = 219397.073$   
 $f_c = 33.00$   
 $\alpha_1 = 0.002$   
Final value of  $\mu_u$ :  $\mu_u^* = \text{shear\_factor} * \max(\mu_u, \alpha_1) = 0.01053874$   
The Shear\_factor is considered equal to 1 (pure moment strength)  
From (5.4b), TBDY:  $\mu_u = 0.01053874$

```

we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00

```

```

s1 = 100.00

```

```

s2 = 250.00

```

```

fywe1 = 694.45

```

```

fywe2 = 694.45

```

```

fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00263293

```

```

c = confinement factor = 1.06329

```

```

y1 = 0.0025

```

```

sh1 = 0.008

```

```

ft1 = 833.34

```

```

fy1 = 694.45

```

```

su1 = 0.032

```

```

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

```

```

lo/lou,min = lb/lb = 1.00

```

```

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

```

```

From table 5A.1, TBDY: esu1_nominal = 0.08,

```

```

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

```

```

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^ 2/3), from 10.3.5, ASCE 41-17.

```

```

with fs1 = (fsjacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

```

```

with Es1 = (Esjacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

```

```

y2 = 0.0025

```

```

sh2 = 0.008

```

```

ft2 = 833.34

```

```

fy2 = 694.45

```

```

su2 = 0.032

```

```

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

```

```

lo/lou,min = lb/lb,min = 1.00

```

```

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

```

```

From table 5A.1, TBDY: esu2_nominal = 0.08,

```

For calculation of  $es_{u2\_nominal}$  and  $y_2$ ,  $sh_2$ ,  $ft_2$ ,  $fy_2$ , it is considered characteristic value  $fs_{y2} = fs_2/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

with  $Es_2 = (Es_{jacket} \cdot Asl_{com,jacket} + Es_{core} \cdot Asl_{com,core}) / Asl_{com} = 200000.00$

$y_v = 0.0025$   
 $sh_v = 0.008$   
 $ft_v = 833.34$   
 $fy_v = 694.45$   
 $suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor and also multiplied by the shear\_factor according to 15.7.1.4, with Shear\_factor = 1.00

$l_o/l_{ou,min} = l_b/l_d = 1.00$   
 $suv = 0.4 \cdot es_{u\_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $es_{u\_nominal} = 0.08$ , considering characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY

For calculation of  $es_{u\_nominal}$  and  $y_v$ ,  $sh_v$ ,  $ft_v$ ,  $fy_v$ , it is considered characteristic value  $fs_{yv} = fs_v/1.2$ , from table 5.1, TBDY.

$y_1$ ,  $sh_1$ ,  $ft_1$ ,  $fy_1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

with  $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.60153764$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.60153764$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.8110188$

and confined core properties:

$b = 170.00$   
 $d = 157.00$   
 $d' = 13.00$   
 $f_{cc} (5A.2, TBDY) = 35.08866$   
 $cc (5A.5, TBDY) = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$   
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.77530517$   
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.77530517$   
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture  
 ' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$  - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover  
 ' satisfies Eq. (4.4)

--->

$v < s_{y1}$  - LHS eq.(4.7) is not satisfied

--->

$v < v_{c,y1}$  - RHS eq.(4.6) is satisfied

--->

$cu (4.10) = 0.45915168$   
 $M_{Rc} (4.17) = 1.5179E+008$

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- $b$ ,  $d$ ,  $d'$  replaced by geometric parameters of the core:  $b_o$ ,  $d_o$ ,  $d'_o$
- $N$ ,  $1$ ,  $2$ ,  $v$  normalised to  $b_o \cdot d_o$ , instead of  $b \cdot d$
- parameters of confined concrete,  $f_{cc}$ ,  $cc$ , used in lieu of  $f_c$ ,  $ecu$

--->

Subcase: Rupture of tension steel

--->

$v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

```

---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----

Calculation of Mu1-
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----

with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233
-----

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00
-----

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00

```



$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.5), \text{TB DY}), \text{TB DY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_1 \text{ nominal} = 0.08,$$

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, TB DY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

$$\text{with } Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esu_2 \text{ nominal} = 0.08,$$

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, TB DY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

$$\text{with } Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

$$\text{From table 5A.1, TB DY: } esuv \text{ nominal} = 0.08,$$

considering characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TB DY  
For calculation of  $esuv \text{ nominal}$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered  
characteristic value  $fsyv = fsv/1.2$ , from table 5.1, TB DY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 * (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

$$\text{with } Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.60153764$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.60153764$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, \text{TB DY}) = 35.08866$$

```

cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----
Calculation of Mu2+
-----
-----
-----
Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008
-----
with full section properties:
b = 200.00
d = 172.00
d' = 28.00

```

$v = 0.19326733$   
 $N = 219397.073$   
 $fc = 33.00$   
 $co (5A.5, TBDY) = 0.002$   
 Final value of  $cu$ :  $cu^* = shear\_factor * Max(cu, cc) = 0.01053874$   
 The Shear\_factor is considered equal to 1 (pure moment strength)  
 From (5.4b), TBDY:  $cu = 0.01053874$   
 $we (5.4c) = 0.03096488$   
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$   
 $ase1 = 0.16608997$   
 $bo\_1 = 170.00$   
 $ho\_1 = 170.00$   
 $bi2\_1 = 115600.00$   
 $ase2 = Max(ase1, ase2) = 0.16608997$   
 $bo\_2 = 92.00$   
 $ho\_2 = 92.00$   
 $bi2\_2 = 33856.00$   
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$   
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$   
 $Ash1 = Astir\_1 * ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$   
 $Ash2 = Astir\_2 * ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

$A_{sec} = 40000.00$   
 $s1 = 100.00$   
 $s2 = 250.00$   
 $fywe1 = 694.45$   
 $fywe2 = 694.45$   
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY:  $cc = 0.00263293$   
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$   
 $sh1 = 0.008$   
 $ft1 = 833.34$   
 $fy1 = 694.45$   
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
 and also multiplied by the shear\_factor according to 15.7.1.4, with  
 $Shear\_factor = 1.00$

$lo/lo_{u,min} = lb/ld = 1.00$

$su1 = 0.4 * esu1\_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY:  $esu1\_nominal = 0.08$ ,

For calculation of  $esu1\_nominal$  and  $y1, sh1, ft1, fy1$ , it is considered  
 characteristic value  $fsy1 = fs1 / 1.2$ , from table 5.1, TBDY.

$y1, sh1, ft1, fy1$ , are also multiplied by  $Min(1, 1.25 * (lb/ld)^{2/3})$ , from 10.3.5, ASCE 41-17.

with  $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 694.45$

with  $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.0025$   
 $sh2 = 0.008$   
 $ft2 = 833.34$   
 $fy2 = 694.45$

```

su2 = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < sy1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->

```

Subcase: Rupture of tension steel

--->

$v^* < v^*_{s,y2}$  - LHS eq.(4.5) is not satisfied

--->

$v^* < v^*_{s,c}$  - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$  - LHS eq.(4.6) is satisfied

--->

$\mu_{cu}$  (4.12) = 0.51649622

$M_{Ro}$  (4.16) = 1.3727E+008

--->

$u = \mu_{cu}$  (4.2) = 3.2469244E-005

$\mu_u = M_{Ro}$

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

Calculation of  $\mu_{u2}$ -

Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:

$u = 3.2469244E-005$

$\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

$\mu_{co}$  (5A.5, TBDY) = 0.002

Final value of  $\mu_{cu}$ :  $\mu_{cu}^* = \text{shear\_factor} * \text{Max}(\mu_{cu}, \mu_{cc}) = 0.01053874$

The Shear\_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY:  $\mu_{cu} = 0.01053874$

$\mu_{we}$  (5.4c) = 0.03096488

$\mu_{ase}$  ((5.4d), TBDY) =  $(\mu_{ase1} * A_{ext} + \mu_{ase2} * A_{int}) / A_{sec} = 0.16608997$

$\mu_{ase1} = 0.16608997$

$b_{o\_1} = 170.00$

$h_{o\_1} = 170.00$

$b_{i2\_1} = 115600.00$

$\mu_{ase2} = \text{Max}(\mu_{ase1}, \mu_{ase2}) = 0.16608997$

$b_{o\_2} = 92.00$

$h_{o\_2} = 92.00$

$b_{i2\_2} = 33856.00$

$\mu_{psh,min} * F_{ywe} = \text{Min}(\mu_{psh,x} * F_{ywe}, \mu_{psh,y} * F_{ywe}) = 6.15233$

$\mu_{psh,x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{ps2} * F_{ywe2} = 6.15233$

$\mu_{ps1}$  (external) =  $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir\_1} * n_{s\_1} = 157.0796$

No stirups,  $n_{s\_1} = 2.00$

$h_1 = 200.00$

$\mu_{ps2}$  (internal) =  $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

$A_{sh2} = A_{stir\_2} * n_{s\_2} = 100.531$

No stirups,  $n_{s\_2} = 2.00$

$h_2 = 100.00$

$\mu_{psh,y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{ps2} * F_{ywe2} = 6.15233$

$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$   
 $Ash1 = Astir\_1 \cdot ns\_1 = 157.0796$   
 No stirups,  $ns\_1 = 2.00$   
 $h1 = 200.00$   
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$   
 $Ash2 = Astir\_2 \cdot ns\_2 = 100.531$   
 No stirups,  $ns\_2 = 2.00$   
 $h2 = 100.00$

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4\*esu1\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1\_nominal = 0.08,

For calculation of esu1\_nominal and y1, sh1,ft1,fy1, it is considered  
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket\*Asl,ten,jacket + fs,core\*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket\*Asl,ten,jacket + Es,core\*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4\*esu2\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2\_nominal = 0.08,

For calculation of esu2\_nominal and y2, sh2,ft2,fy2, it is considered  
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket\*Asl,com,jacket + fs,core\*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket\*Asl,com,jacket + Es,core\*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear\_factor  
and also multiplied by the shear\_factor according to 15.7.1.4, with  
Shear\_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4\*esuv\_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv\_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv\_nominal and yv, shv,ftv,fyv, it is considered  
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by  $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$ , from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket\*Asl,mid,jacket + fs,mid\*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket\*Asl,mid,jacket + Es,mid\*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b\*d)\*(fs1/fc) = 0.60153764

```

2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < s,y1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 200506.935
-----
Calculation of Shear Strength at edge 1, Vr1 = 200506.935
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO

```

VCol0 = 200506.935  
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0213315E-011$   
 $V_u = 1.9686856E-030$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by Col1 = 1.00  
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$   
 $V_{s2}$  is multiplied by Col2 = 0.00  
 $s/d = 3.125$   
 $V_f$  ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440:  $V_s + V_f \leq 122116.319$   
 $b_w = 200.00$

Calculation of Shear Strength at edge 2,  $V_{r2} = 200506.935$   
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = \text{knl} \cdot V_{\text{Col0}}$   
 $V_{\text{Col0}} = 200506.935$   
 $\text{knl} = 1$  (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '  
where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)  
Mean concrete strength:  $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)  
 $M/Vd = 2.00$   
 $\mu_u = 2.0213315E-011$   
 $V_u = 1.9686856E-030$   
 $d = 0.8 \cdot h = 160.00$   
 $N_u = 219397.073$   
 $A_g = 40000.00$   
From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 139627.457$   
where:  
 $V_{s1} = 139627.457$  is calculated for jacket, with:  
 $d = 160.00$   
 $A_v = 157079.633$   
 $f_y = 555.56$   
 $s = 100.00$   
 $V_{s1}$  is multiplied by Col1 = 1.00  
 $s/d = 0.625$   
 $V_{s2} = 0.00$  is calculated for core, with:  
 $d = 80.00$   
 $A_v = 100530.965$   
 $f_y = 555.56$   
 $s = 250.00$



Vs2 is multiplied by Col2 = 0.00  
s/d = 3.125  
Vf ((11-3)-(11.4), ACI 440) = 0.00  
From (11-11), ACI 440: Vs + Vf <= 122116.319  
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1  
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1  
At local axis: 2  
Integration Section: (b)  
Section Type: rcjrs

#### Constant Properties

Knowledge Factor,  $\gamma = 1.00$   
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.  
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at  $135^\circ$ )  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_b/l_d >= 1$ )  
No FRP Wrapping

#### Stepwise Properties

Bending Moment,  $M = -9.0143946E-008$   
Shear Force,  $V_2 = 37594.437$   
Shear Force,  $V_3 = -6.2539570E-011$   
Axial Force,  $F = -218084.658$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $As_t = 0.00$   
-Compression:  $As_c = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten} = 983.3185$   
-Compression:  $As_{l,com} = 983.3185$   
-Middle:  $As_{l,mid} = 1325.752$   
Longitudinal External Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $As_{t,ten,jacket} = 829.3805$   
-Compression:  $As_{l,com,jacket} = 829.3805$   
-Middle:  $As_{l,mid,jacket} = 402.1239$   
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension:  $Asl_{ten,core} = 153.938$   
-Compression:  $Asl_{com,core} = 153.938$   
-Middle:  $Asl_{mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement,  $DbL = 17.50$

New component: From table 7-7, ASCE 41\_17: Final chord rotation Capacity  $u_R = 1.0^*$   $u = 0.07272853$   
 $u = y + p = 0.07272853$

- Calculation of  $y$  -

$y = (My * L_s / 3) / E_{eff} = 0.03857221$  ((4.29), Biskinis Phd))  
 $My = 1.0143E+008$   
 $L_s = M/V$  (with  $L_s > 0.1 * L$  and  $L_s < 2 * L$ ) = 1500.00  
From table 10.5, ASCE 41\_17:  $E_{eff} = factor * E_c * I_g = 1.3147E+012$   
 $factor = 0.36521565$   
 $Ag = 40000.00$   
Mean concrete strength:  $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$   
 $N = 218084.658$   
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $My$

Calculation of  $y$  and  $My$  according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$   
 $y_{ten} = 3.1087819E-005$   
with  $f_y = 555.56$   
 $d = 172.00$   
 $y = 0.48050392$   
 $A = 0.1071203$   
 $B = 0.06705607$   
with  $pt = 0.02858484$   
 $pc = 0.02858484$   
 $pv = 0.03853931$   
 $N = 218084.658$   
 $b = 200.00$   
 $" = 0.1627907$   
 $y_{comp} = 2.6249185E-005$   
with  $fc = 33.00$   
 $E_c = 26999.444$   
 $y = 0.48728983$   
 $A = 0.08130094$   
 $B = 0.05564476$   
with  $E_s = 200000.00$

Calculation of ratio  $l_b/d$

Adequate Lap Length:  $l_b/d \geq 1$

- Calculation of  $p$  -

From table 10-8:  $p = 0.03415631$

with:

- Columns not controlled by inadequate development or splicing along the clear height because  $l_b/d \geq 1$   
shear control ratio  $V_y E / V_{col} E = 0.4563967$   
 $d = d_{external} = 172.00$   
 $s = s_{external} = 150.00$   
 $t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00885929$   
jacket:  $s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00785398$

$A_{v1} = 157.0796$ , is the total area of all stirrups parallel to loading (shear) direction

$h1 = 200.00$

$s1 = 100.00$

core:  $s2 = A_{v2} \cdot h2 / (s2 \cdot A_g) = 0.00100531$

$A_{v2} = 100.531$ , is the total area of all stirrups parallel to loading (shear) direction

$h2 = 100.00$

$s2 = 250.00$

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.

$N_{UD} = 218084.658$

$A_g = 40000.00$

$f_{cE} = (f_{c\_jacket} \cdot Area\_jacket + f_{c\_core} \cdot Area\_core) / section\_area = 33.00$

$f_{yE} = (f_{y\_ext\_Long\_Reinf} \cdot Area\_ext\_Long\_Reinf + f_{y\_int\_Long\_Reinf} \cdot Area\_int\_Long\_Reinf) / Area\_Tot\_Long\_Rein = 555.56$

$f_{yE} = (f_{y\_ext\_Trans\_Reinf} \cdot s1 + f_{y\_int\_Trans\_Reinf} \cdot s2) / (s1 + s2) = 555.56$

$\rho_l = Area\_Tot\_Long\_Rein / (b \cdot d) = 0.09570899$

$b = 200.00$

$d = 172.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

## Calculation No. 15

column C1, Floor 1

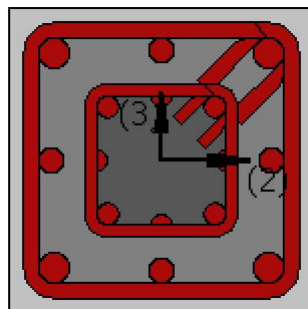
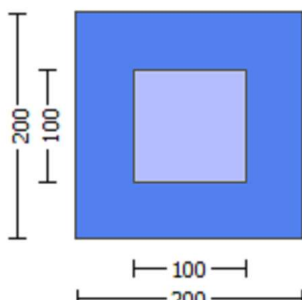
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity  $V_{Rd}$

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1  
At local axis: 3  
Integration Section: (b)  
Section Type: rcjrs

Constant Properties

---

Knowledge Factor,  $\phi = 1.00$   
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.  
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17  
Consequently:  
Jacket  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
Existing Column  
New material of Secondary Member: Concrete Strength,  $f_c = f_{c\_lower\_bound} = 25.00$   
New material of Secondary Member: Steel Strength,  $f_s = f_{s\_lower\_bound} = 500.00$   
Concrete Elasticity,  $E_c = 26999.444$   
Steel Elasticity,  $E_s = 200000.00$   
#####  
Note: Especially for the calculation of  $\phi$  for displacement ductility demand,  
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as  
Deformation-Controlled Action (Table C7-1, ASCE 41-17).  
Jacket  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
Existing Column  
New material: Concrete Strength,  $f_c = f_{cm} = 33.00$   
New material: Steel Strength,  $f_s = f_{sm} = 555.56$   
#####  
External Height,  $H = 200.00$   
External Width,  $W = 200.00$   
Internal Height,  $H = 100.00$   
Internal Width,  $W = 100.00$   
Cover Thickness,  $c = 10.00$   
Element Length,  $L = 3000.00$   
Secondary Member  
Smooth Bars  
Ductile Steel  
With Detailing for Earthquake Resistance (including stirrups closed at 135°)  
Longitudinal Bars With Ends Lapped Starting at the End Sections  
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d \geq 1$ )  
No FRP Wrapping

---

Stepwise Properties

---

EDGE -A-  
Bending Moment,  $M_a = -9.9495397E-008$   
Shear Force,  $V_a = 6.2539570E-011$   
EDGE -B-  
Bending Moment,  $M_b = -9.0143946E-008$   
Shear Force,  $V_b = -6.2539570E-011$   
BOTH EDGES  
Axial Force,  $F = -218084.658$   
Longitudinal Reinforcement Area Distribution (in 2 divisions)  
-Tension:  $A_{sl,t} = 0.00$   
-Compression:  $A_{sl,c} = 3292.389$   
Longitudinal Reinforcement Area Distribution (in 3 divisions)  
-Tension:  $A_{sl,ten} = 983.3185$   
-Compression:  $A_{sl,com} = 983.3185$   
-Middle:  $A_{sl,mid} = 1325.752$   
Mean Diameter of Tension Reinforcement,  $Db_{L,ten} = 17.50$

---



---

New component: From table 7-7, ASCE 41\_17: Final Shear Capacity  $V_R = 1.0 \cdot V_n = 177628.325$

$V_n$  ((10.3), ASCE 41-17) =  $k_n \cdot V_{Col} = 177628.325$

$V_{Col} = 177628.325$

$k_n = 1.00$

displacement\_ductility\_demand = 2.2204460E-016

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '

where  $V_f$  is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $f_c'^{0.5} \leq 8.3$  MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 9.0143946E-008$

$\nu_u = 6.2539570E-011$

$d = 0.8 \cdot h = 160.00$

$N_u = 218084.658$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14:  $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$  is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

$V_{s1}$  is multiplied by  $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$  is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

$V_{s2}$  is multiplied by  $Col2 = 0.00$

$s/d = 3.125$

$V_f$  ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440:  $V_s + V_f \leq 106288.613$

$b_w = 200.00$

displacement\_ductility\_demand is calculated as  $\gamma / y$

- Calculation of  $\gamma / y$  for END B -

for rotation axis 2 and integ. section (b)

From analysis, chord rotation  $\theta = 4.2143303E-018$

$\gamma = (M_y \cdot L_s / 3) / E_{eff} = 0.03857221$  ((4.29), Biskinis Phd))

$M_y = 1.0143E+008$

$L_s = M/V$  (with  $L_s > 0.1 \cdot L$  and  $L_s < 2 \cdot L$ ) = 1500.00

From table 10.5, ASCE 41\_17:  $E_{eff} = factor \cdot E_c \cdot I_g = 1.3147E+012$

factor = 0.36521565

$A_g = 40000.00$

Mean concrete strength:  $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$

$N = 218084.658$

$E_c \cdot I_g = E_{c,jacket} \cdot I_{g,jacket} + E_{c,core} \cdot I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment  $M_y$

Calculation of  $\gamma$  and  $M_y$  according to Annex 7 -

$\gamma = \min(\gamma_{ten}, \gamma_{com})$

$\gamma_{ten} = 3.1087819E-005$

with  $f_y = 555.56$

d = 172.00  
y = 0.48050392  
A = 0.1071203  
B = 0.06705607  
with pt = 0.02858484  
pc = 0.02858484  
pv = 0.03853931  
N = 218084.658  
b = 200.00  
" = 0.1627907  
y\_comp = 2.6249185E-005  
with fc = 33.00  
Ec = 26999.444  
y = 0.48728983  
A = 0.08130094  
B = 0.05564476  
with Es = 200000.00

Calculation of ratio  $l_b/l_d$

Adequate Lap Length:  $l_b/l_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)