

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

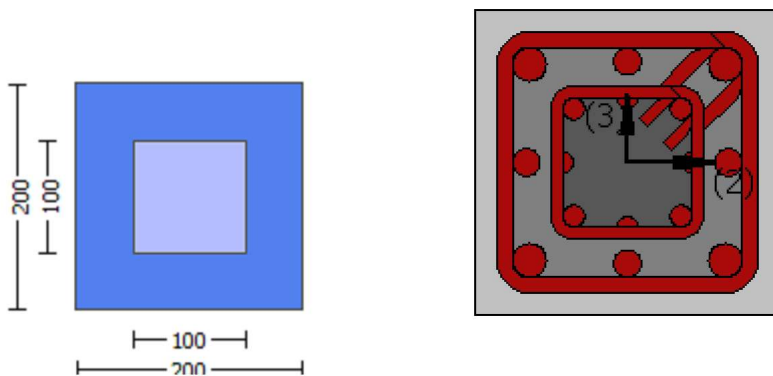
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

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, $f_s = f_{s_lower_bound} = 500.00$

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Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of  $\mu_y$  for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
#####
External Height, H = 200.00
External Width, W = 200.00
Internal Height, H = 100.00
Internal Width, W = 100.00
Cover Thickness, c = 15.00
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
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Stepwise Properties
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EDGE -A-
Bending Moment, Ma = -2.2562E+008
Shear Force, Va = -2372.544
EDGE -B-
Bending Moment, Mb = -573480.362
Shear Force, Vb = 2372.544
BOTH EDGES
Axial Force, F = -952838.426
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 1476.549
-Compression: Aslc = 2293.363
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1476.549
-Compression: Asl,com = 1476.549
-Middle: Asl,mid = 816.8141
Mean Diameter of Tension Reinforcement, DbL,ten = 17.33333
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New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 171057.547
Vn ((10.3), ASCE 41-17) = knl*VCol = 171057.547
VCol = 171057.547
knl = 1.00
displacement_ductility_demand = 1.01651
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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).
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= 1 (normal-weight concrete)
Mean concrete strength:  $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 25.00$ , but  $fc'^{0.5} \leq 8.3$ 
MPa (22.5.3.1, ACI 318-14)

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$M/Vd = 4.00$
 $\mu_u = 2.2562E+008$
 $V_u = 2372.544$
 $d = 0.8 \cdot h = 160.00$
 $N_u = 952838.426$
 $A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 106288.613$
 $b_w = 200.00$

displacement ductility demand is calculated as δ_u / y

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

From analysis, chord rotation $\theta_r = 0.07658823$
 $y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.07534453 ((4.29), \text{Biskinis Phd})$
 $M_y = 9.4932E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 6000.00
 From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 2.5199E+012$
 $\text{factor} = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$
 $N = 952838.426$
 $E_c \cdot I_g = E_c \cdot I_{g_{\text{jacket}}} + E_c \cdot I_{g_{\text{core}}} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of δ_u and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 4.0448288E-005$
 with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58629312$
 $A = 0.16521104$
 $B = 0.12006404$
 with $p_t = 0.04447435$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
 $N = 952838.426$
 $b = 200.00$
 $\rho = 0.20481928$
 $y_{\text{comp}} = 1.8654349E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.71046623$

A = 0.04832572
B = 0.06840454
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

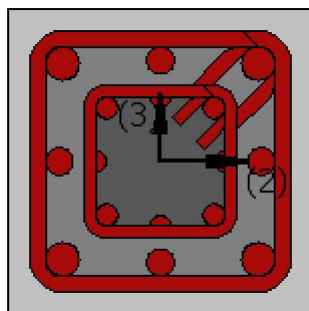
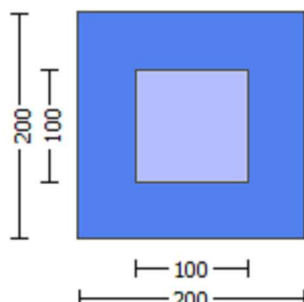
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $E_s = 200000.00$

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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,  $c = 15.00$ 
Mean Confinement Factor overall section = 1.02878
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
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Stepwise Properties
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At local axis: 3
EDGE -A-
Shear Force,  $V_a = -1.1598602E-029$ 
EDGE -B-
Shear Force,  $V_b = 1.1598602E-029$ 
BOTH EDGES
Axial Force,  $F = -954435.753$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $As_t = 0.00$ 
-Compression:  $As_c = 3769.911$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $As_{t,ten} = 1476.549$ 
-Compression:  $As_{l,com} = 1476.549$ 
-Middle:  $As_{l,mid} = 816.8141$ 
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Calculation of Shear Capacity ratio ,  $V_e/V_r = 0.43225659$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$ 
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$ 
 $\mu_{u1+} = 1.6991E+008$ , 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
 $\mu_{u1-} = 1.6991E+008$ , 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$ 
 $\mu_{u2+} = 1.6991E+008$ , 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
 $\mu_{u2-} = 1.6991E+008$ , 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
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Calculation of  $\mu_{u1+}$ 
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Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 8.6451905E-005$$

$$\mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$v = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{ue} \text{ (5.4c)} = 0.03159521$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{se1} = 0.15755208$$

$$\phi_{se1_1} = 160.00$$

$$\phi_{se1_2} = 160.00$$

$$\phi_{se1_3} = 102400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.15755208$$

$$\phi_{se2_1} = 92.00$$

$$\phi_{se2_2} = 92.00$$

$$\phi_{se2_3} = 33856.00$$

$$\phi_{sh,min} * F_{ywe} = \text{Min}(\phi_{sh,x} * F_{ywe}, \phi_{sh,y} * F_{ywe}) = 6.61776$$

$$\phi_{sh,x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{sh,y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 833.34$$

$$f_{y1} = 694.45$$

$$su_1 = 0.032$$

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

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

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

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 $Es_v = (Es_jacket \cdot Asl_mid_jacket + Es_mid \cdot Asl_mid_core) / Asl_mid = 200000.00$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 0.93591561$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 0.93591561$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.51774055$
and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_ten / (b \cdot d) \cdot (fs1 / fc) = 1.33015$
 $2 = Asl_com / (b \cdot d) \cdot (fs2 / fc) = 1.33015$
 $v = Asl_mid / (b \cdot d) \cdot (fsv / fc) = 0.73582989$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - 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
--->
 $cu (4.10) = 0.7393216$

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MRC (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRC
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRC

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

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b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

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$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$

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

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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 $fs1 = (fs_jacket * Asl, ten, jacket + fs_core * Asl, ten, core) / Asl, ten = 694.45$

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

$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*cy2 - LHS eq.(4.6) is not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

```

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$\mu = 8.6451905E-005$

$\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

ϕ (5A.5, TBDY) = 0.002

Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \phi) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\mu_u = 0.01061002$

μ_{ue} (5.4c) = 0.03159521

μ_{se} ((5.4d), TBDY) = $(\mu_{se1} * A_{ext} + \mu_{se2} * A_{int}) / A_{sec} = 0.15755208$

$\mu_{se1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$\mu_{se2} = \text{Max}(\mu_{se1}, \mu_{se2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$\mu_{sh,min} * F_{ywe} = \text{Min}(\mu_{sh,x} * F_{ywe}, \mu_{sh,y} * F_{ywe}) = 6.61776$

$\mu_{sh,x} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 6.61776$

μ_{sh1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

μ_{sh2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$\mu_{sh,y} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 6.61776$

μ_{sh1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

μ_{sh2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 150.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $\phi_c = 0.00228783$

ϕ_c = confinement factor = 1.02878

$y_1 = 0.0025$

```

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/lo,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/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/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/lo,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,min)^ 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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
 $M_{Rc}$  (4.17) = 1.6991E+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 not satisfied
---->
 $v^* < v^* c, y1$  - RHS eq.(4.6) is not satisfied
---->
 $*c_u$  (4.11) = 0.65248434
 $M_{Ro}$  (4.18) = 1.2423E+008
 $M_{Ro} < 0.8 * M_{Rc}$ 
---->
 $u = c_u$  (unconfined full section) = 8.6451905E-005
 $\mu_u = M_{Rc}$ 
-----

Calculation of ratio  $I_b/I_d$ 
-----
Adequate Lap Length:  $I_b/I_d \geq 1$ 
-----
-----
Calculation of  $\mu_{u2}$ -
-----
-----
Calculation of ultimate curvature  $\mu_u$  according to 4.1, Biskinis/Fardis 2013:
 $u = 8.6451905E-005$ 
 $\mu_u = 1.6991E+008$ 
-----
with full section properties:
 $b = 200.00$ 
 $d = 166.00$ 
 $d' = 34.00$ 
 $v = 0.87115348$ 
 $N = 954435.753$ 
 $f_c = 33.00$ 
 $c_o$  (5A.5, TBDY) = 0.002
Final value of  $c_u$ :  $c_u^* = \text{shear\_factor} * \text{Max}(c_u, c_c) = 0.01061002$ 
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY:  $c_u = 0.01061002$ 
 $w_e$  (5.4c) = 0.03159521
 $a_{se}$  ((5.4d), TBDY) =  $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$ 
 $a_{se1} = 0.15755208$ 

```

$bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 6.61776$

$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 * h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 * h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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

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

$su1 = 0.4 * esu1_nominal ((5.5), \text{ TBDY}) = 0.032$

$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$

$\text{For calculation of } esu1_nominal \text{ and } y1, sh1, ft1, fy1, \text{ it is considered}$
 $\text{characteristic value } fsy1 = fs1 / 1.2, \text{ from table 5.1, TBDY.}$

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

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

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

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

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

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

$su2 = 0.4 * esu2_nominal ((5.5), \text{ TBDY}) = 0.032$

$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$

$\text{For calculation of } esu2_nominal \text{ and } y2, sh2, ft2, fy2, \text{ it is considered}$
 $\text{characteristic value } fsy2 = fs2 / 1.2, \text{ from table 5.1, TBDY.}$

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

```

with 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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->

```

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u(4.11) = 0.65248434$

$MR_o(4.18) = 1.2423E+008$

$MR_o < 0.8*MR_c$

--->

$u = c_u(\text{unconfined full section}) = 8.6451905E-005$

$Mu = MR_c$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{ColO} = 262044.453$

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

$M/Vd = 2.00$

$Mu = 3.6564195E-010$

$Vu = 1.1598602E-029$

$d = 0.8*h = 160.00$

$Nu = 954435.753$

$Ag = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$bw = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$

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

$V_{ColO} = 262044.453$

$k_{nl} = 1$ (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: $f'_c = (f'_c_{\text{jacket}}*Area_{\text{jacket}} + f'_c_{\text{core}}*Area_{\text{core}})/Area_{\text{section}} = 33.00$, but $f'_c^{0.5} \leq 8.3$

MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$V_u = 1.1598602E-029$

$d = 0.8 \cdot h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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, $\phi = 1.00$

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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878
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: 2
EDGE -A-
Shear Force, $V_a = 7.1018611\text{E-}046$
EDGE -B-
Shear Force, $V_b = -7.1018611\text{E-}046$
BOTH EDGES
Axial Force, $F = -954435.753$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1476.549$
-Compression: $As_{c,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.6991\text{E+}008$
 $\mu_{u1+} = 1.6991\text{E+}008$, 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
 $\mu_{u1-} = 1.6991\text{E+}008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.6991\text{E+}008$
 $\mu_{u2+} = 1.6991\text{E+}008$, 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
 $\mu_{u2-} = 1.6991\text{E+}008$, 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 μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.6451905\text{E-}005$
 $\mu_u = 1.6991\text{E+}008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi_o (5A.5, \text{TB DY}) = 0.002$
Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01061002$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TB DY: $\phi_{cu} = 0.01061002$
we (5.4c) = 0.03159521

```

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 150.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00228783
c = confinement factor = 1.02878

```

```

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  $f_{sy2} = f_{s2}/1.2$ , from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , 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  $E_{s2} = (E_{sjacket} \cdot A_{sl,com,jacket} + E_{s,core} \cdot A_{sl,com,core}) / A_{sl,com} = 200000.00$ 
 $y_v = 0.0025$ 
 $sh_v = 0.008$ 
 $ft_v = 833.34$ 
 $fy_v = 694.45$ 
 $suv = 0.032$ 
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
 $l_o/l_{ou,min} = l_b/l_d = 1.00$ 
 $suv = 0.4 \cdot esuv\_nominal ((5.5), TBDY) = 0.032$ 
From table 5A.1, TBDY:  $esuv\_nominal = 0.08$ ,
considering characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY
For calculation of  $esuv\_nominal$  and  $y_v, sh_v, ft_v, fy_v$ , it is considered
characteristic value  $f_{syv} = f_{sv}/1.2$ , from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$ , are also multiplied by  $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$ , from 10.3.5, ASCE 41-17.
with  $f_{sv} = (f_{sjacket} \cdot A_{sl,mid,jacket} + f_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 694.45$ 
with  $E_{sv} = (E_{sjacket} \cdot A_{sl,mid,jacket} + E_{s,mid} \cdot A_{sl,mid,core}) / A_{sl,mid} = 200000.00$ 
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.93591561$ 
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.93591561$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.51774055$ 
and confined core properties:
 $b = 160.00$ 
 $d = 146.00$ 
 $d' = 14.00$ 
 $f_{cc} (5A.2, TBDY) = 33.94983$ 
 $cc (5A.5, TBDY) = 0.00228783$ 
 $c = \text{confinement factor} = 1.02878$ 
 $1 = A_{sl,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 1.33015$ 
 $2 = A_{sl,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 1.33015$ 
 $v = A_{sl,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.73582989$ 
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$  - 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
--->
 $cu (4.10) = 0.7393216$ 
 $M_{Rc} (4.17) = 1.6991E+008$ 
--->
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  $b \cdot d$ 
-  $f_{cc}, cc$ , 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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

*cu (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

M_{Ro} < 0.8*M_{Rc}

--->

u = cu (unconfined full section) = 8.6451905E-005

Mu = M_{Rc}

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 = 8.6451905E-005

Mu = 1.6991E+008

with full section properties:

b = 200.00

d = 166.00

d' = 34.00

v = 0.87115348

N = 954435.753

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01061002

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01061002

we (5.4c) = 0.03159521

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208

ase1 = 0.15755208

bo_1 = 160.00

ho_1 = 160.00

bi2_1 = 102400.00

ase2 = Max(ase1,ase2) = 0.15755208

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776

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 = 0.00167552

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776

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 = 0.00167552

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

$$su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

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

$$\text{with } fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

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

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

$$su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TB DY}) = 0.032$$

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

$$\text{with } fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

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

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

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

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

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

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

$$\text{with } fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

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

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.93591561$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.93591561$$

$$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.51774055$$

and confined core properties:

$$b = 160.00$$

$$d = 146.00$$

$$d' = 14.00$$

$$fcc (5A.2, \text{TB DY}) = 33.94983$$

```

cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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, ec
---->
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 not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00

```

$d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $fc = 33.00$
 $co(5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01061002$
 $we(5.4c) = 0.03159521$
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.61776$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$
 $lo/lo_{u, \min} = lb/d = 1.00$

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

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

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

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/d)^{2/3})$, 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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
    c = confinement factor = 1.02878
    1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
    2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
    v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776
-----
psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

$psh_y \cdot F_{ywe} = psh1 \cdot F_{ywe1} + ps2 \cdot F_{ywe2} = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$

$s1 = 100.00$

$s2 = 150.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$

$c = \text{confinement factor} = 1.02878$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

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

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 $fsv = (fs_jacket \cdot Asl, \text{mid}, \text{jacket} + fs_mid \cdot Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 694.45$

```

with Esv = (Esjacket*Aslmid,jacket + Esmid*Aslmid,core)/Aslmid = 200000.00
1 = Aslten/(b*d)*(fs1/fc) = 0.93591561
2 = Aslcom/(b*d)*(fs2/fc) = 0.93591561
v = Aslmid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Aslten/(b*d)*(fs1/fc) = 1.33015
2 = Aslcom/(b*d)*(fs2/fc) = 1.33015
v = Aslmid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*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 not satisfied
--->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
-----
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 262044.453

```

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

$V_{r1} = V_{col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{col0}$

$V_{col0} = 262044.453$

$k_{nl} = 1$ (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)

$M / Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$

$V_{r2} = V_{col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{col0}$

$V_{col0} = 262044.453$

$k_{nl} = 1$ (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)

$M / Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

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

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

Consequently:

Jacket

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

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

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

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

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

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

External Height, H = 200.00

External Width, W = 200.00

Internal Height, H = 100.00

Internal Width, W = 100.00

Cover Thickness, c = 15.00

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 (lb/ld >= 1)

No FRP Wrapping

Stepwise Properties

Bending Moment, M = -3.7448736E-006

Shear Force, V2 = -2372.544

Shear Force, V3 = -4.1216227E-010

Axial Force, F = -952838.426

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 1476.549

-Compression: Aslc = 2293.363

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten = 1476.549

-Compression: Asl,com = 1476.549

-Middle: Asl,mid = 816.8141

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: Asl,ten,jacket = 1014.734

-Compression: $Asl,com,jacket = 1014.734$

-Middle: $Asl,mid,jacket = 508.938$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl,ten,core = 461.8141$

-Compression: $Asl,com,core = 461.8141$

-Middle: $Asl,mid,core = 307.8761$

Mean Diameter of Tension Reinforcement, $DbL = 17.33333$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^*$ $u = 0.01988947$

$u = y + p = 0.01988947$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.01883613$ ((4.29),Biskinis Phd))

$My = 9.4932E+007$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 2.5199E+012$

$factor = 0.70$

$Ag = 40000.00$

Mean concrete strength: $fc' = (fc'_jacket * Area_jacket + fc'_core * Area_core) / Area_section = 33.00$

$N = 952838.426$

$Ec * Ig = Ec_jacket * Ig_jacket + Ec_core * Ig_core = 3.5999E+012$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_ten, y_com)$

$y_ten = 4.0448288E-005$

with $fy = 555.56$

$d = 166.00$

$y = 0.58629312$

$A = 0.16521104$

$B = 0.12006404$

with $pt = 0.0095295$

$pc = 0.04447435$

$pv = 0.02460283$

$N = 952838.426$

$b = 200.00$

$" = 0.20481928$

$y_comp = 1.8654349E-005$

with $fc = 33.00$

$Ec = 26999.444$

$y = 0.71046623$

$A = 0.04832572$

$B = 0.06840454$

with $Es = 200000.00$

Calculation of ratio lb/d

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

- Calculation of p -

From table 10-8: $p = 0.00105334$

with:

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

shear control ratio $VyE/VColOE = 0.43225659$

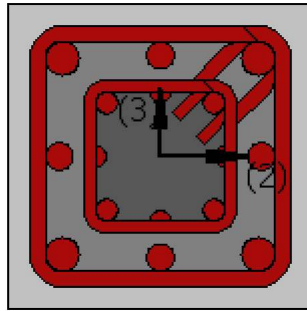
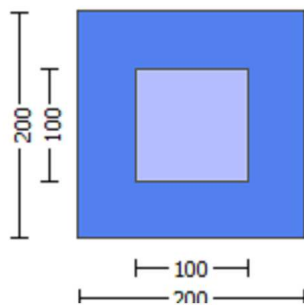
$d = d_external = 166.00$

$s = s_{\text{external}} = 150.00$
 $t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.0095295$
 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: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00167552$
 $A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction
 $h_2 = 100.00$
 $s_2 = 150.00$
 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.
 $NUD = 952838.426$
 $A_g = 40000.00$
 $f_{cE} = (f_{c,jacket} \cdot \text{Area}_{jacket} + f_{c,core} \cdot \text{Area}_{core}) / \text{section_area} = 33.00$
 $f_{yE} = (f_{y,ext_Long_Reinf} \cdot \text{Area}_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot \text{Area}_{int_Long_Reinf}) / \text{Area}_{Tot_Long_Rein} = 555.56$
 $f_{yE} = (f_{y,ext_Trans_Reinf} \cdot \text{Area}_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot \text{Area}_{int_Trans_Reinf}) / \text{Area}_{Tot_Trans_Rein} = 555.56$
 $\rho_l = \text{Area}_{Tot_Long_Rein} / (b \cdot d) = 0.11355154$
 $b = 200.00$
 $d = 166.00$
 $f_{cE} = 33.00$

 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 VRd
 Edge: Start
 Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $c = 15.00$

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, $M_a = -3.7448736E-006$

Shear Force, $V_a = -4.1216227E-010$

EDGE -B-
 Bending Moment, Mb = 5.8770792E-007
 Shear Force, Vb = 4.1216227E-010
 BOTH EDGES
 Axial Force, F = -952838.426
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 1476.549
 -Compression: Aslc = 2293.363
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1476.549
 -Compression: Asl,com = 1476.549
 -Middle: Asl,mid = 816.8141
 Mean Diameter of Tension Reinforcement, DbL,ten = 17.33333

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 235826.482
 Vn ((10.3), ASCE 41-17) = knl*VColO = 235826.482
 VCol = 235826.482
 knl = 1.00
 displacement_ductility_demand = 8.1601392E-014

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

 = 1 (normal-weight concrete)
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
 Mu = 3.7448736E-006
 Vu = 4.1216227E-010
 d = 0.8*h = 160.00
 Nu = 952838.426
 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 = 150.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.875
 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 / y

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

 From analysis, chord rotation = 1.5355735E-015
 y = (My*Ls/3)/Eleff = 0.01883613 ((4.29),Biskinis Phd))
 My = 9.4932E+007
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.5199E+012

factor = 0.70
Ag = 40000.00
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$
N = 952838.426
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.0448288E-005$
with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58629312$
 $A = 0.16521104$
 $B = 0.12006404$
with $p_t = 0.04447435$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
N = 952838.426
 $b = 200.00$
 $" = 0.20481928$
 $y_{comp} = 1.8654349E-005$
with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.71046623$
 $A = 0.04832572$
 $B = 0.06840454$
with $Es = 200000.00$

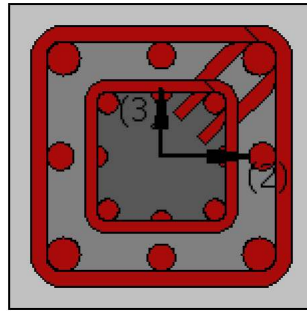
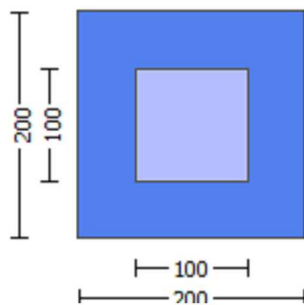
Calculation of ratio I_b/I_d

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: 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 (ϕ_r)
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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878

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, $V_a = -1.1598602E-029$

EDGE -B-

Shear Force, $V_b = 1.1598602E-029$

BOTH EDGES

Axial Force, $F = -954435.753$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3769.911$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1476.549$

-Compression: $As_{c,com} = 1476.549$

-Middle: $As_{mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.6991\text{E}+008$

$\mu_{1+} = 1.6991\text{E}+008$, 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

$\mu_{1-} = 1.6991\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.6991\text{E}+008$

$\mu_{2+} = 1.6991\text{E}+008$, 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

$\mu_{2-} = 1.6991\text{E}+008$, 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 μ_{1+}

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

$\phi_u = 8.6451905\text{E}-005$

$M_u = 1.6991\text{E}+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01061002$

we (5.4c) = 0.03159521

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$

$ase1 = 0.15755208$

$bo_1 = 160.00$

$ho_1 = 160.00$

$bi2_1 = 102400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.15755208$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi2_2 = 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.61776$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$

$ps1$ (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) = $(Ash2 * h2 / s2) / A_{sec} = 0.00167552$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu1-

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

$$\phi_u = 8.6451905E-005$$

$$\mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

$$\phi_{0.5A} (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{we} (5.4c) = 0.03159521$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{ase1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

$psh_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

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

$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$, 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
 $Shear_factor = 1.00$

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

$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$, 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
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,
considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $e_{suv,nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$
with $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.93591561$
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.93591561$
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.51774055$
and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 1.33015$
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 1.33015$
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.73582989$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - 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
--->
 $c_u (4.10) = 0.7393216$
 $M_{Rc} (4.17) = 1.6991E+008$
--->
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} , cc , used in lieu of f_c , e_{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 not satisfied
--->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied
--->
 $*c_u (4.11) = 0.65248434$
 $M_{Ro} (4.18) = 1.2423E+008$
 $M_{Ro} < 0.8 * M_{Rc}$
--->
 $u = c_u$ (unconfined full section) = $8.6451905E-005$
 $M_u = M_{Rc}$

Calculation of ratio l_b/d

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

Calculation of Mu_2

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

$$\phi_u = 8.6451905E-005$$

$$Mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$v = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_o) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{ue} \text{ (5.4c)} = 0.03159521$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{se1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.61776$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00228783$$

$$\phi_c = \text{confinement factor} = 1.02878$$

```

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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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*d_o , instead of $b*d$
- parameters of confined concrete, f_{cc} , ϵ_{cc} , used in lieu of f_c , ϵ_{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 not satisfied

---->

$v^* < v^*c, y1$ - RHS eq.(4.6) is not satisfied

---->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8*M_{Rc}$

---->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$\mu_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{Co10} = 262044.453$

$k_{nl} = 1$ (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)

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$V_u = 1.1598602E-029$

$d = 0.8*h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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 = 262044.453

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

VCol0 = 262044.453

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 = 3.6564195E-010

Vu = 1.1598602E-029

d = 0.8*h = 160.00

Nu = 954435.753

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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, $\gamma = 1.00$

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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878

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, $V_a = 7.1018611E-046$

EDGE -B-

Shear Force, $V_b = -7.1018611E-046$

BOTH EDGES

Axial Force, $F = -954435.753$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3769.911$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1476.549$

-Compression: $A_{st,com} = 1476.549$

-Middle: $A_{st,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6991E+008$

$M_{u1+} = 1.6991E+008$, 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

$\text{Mu1-} = 1.6991\text{E}+008$, 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

$\text{Mpr2} = \text{Max}(\text{Mu2+}, \text{Mu2-}) = 1.6991\text{E}+008$

$\text{Mu2+} = 1.6991\text{E}+008$, 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

$\text{Mu2-} = 1.6991\text{E}+008$, 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 Mu1+

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

$\phi_u = 8.6451905\text{E}-005$

$\text{Mu} = 1.6991\text{E}+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01061002$

$\phi_{we} (5.4c) = 0.03159521$

$\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$

$\phi_{ase1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$

$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$

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

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$

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

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 150.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
 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 $Es_v = (Es_jacket * Asl, \text{mid}, \text{jacket} + Es_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.93591561$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.93591561$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 1.33015$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 1.33015$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->

```

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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002

```

```

we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00

```

```

s1 = 100.00

```

```

s2 = 150.00

```

```

fywe1 = 694.45

```

```

fywe2 = 694.45

```

```

fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00228783

```

```

c = confinement factor = 1.02878

```

```

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

$lo/lou_{min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, 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 $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.94983$
 $cc \text{ (5A.5, TBDY)} = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu \text{ (4.10)} = 0.7393216$
 $M_{Rc} \text{ (4.17)} = 1.6991E+008$

--->

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, 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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,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 $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, 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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00


```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi (5A.5, TBDY) = 0.002$
 Final value of ϕ : $\phi^* = \text{shear_factor} * \text{Max}(\phi, \phi_c) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi = 0.01061002$
 $\phi (5.4c) = 0.03159521$
 $\phi (5.4d), TBDY = (\phi_1 * A_{ext} + \phi_2 * A_{int}) / A_{sec} = 0.15755208$
 $\phi_1 = 0.15755208$
 $b_{o1} = 160.00$
 $h_{o1} = 160.00$
 $b_{i21} = 102400.00$
 $\phi_2 = \text{Max}(\phi_1, \phi_2) = 0.15755208$
 $b_{o2} = 92.00$
 $h_{o2} = 92.00$
 $b_{i22} = 33856.00$
 $\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.61776$

$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$
 $\phi_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir, 1} * n_{s1} = 157.0796$
 No stirrups, $n_{s1} = 2.00$
 $h_1 = 200.00$
 $\phi_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir, 2} * n_{s2} = 100.531$
 No stirrups, $n_{s2} = 2.00$
 $h_2 = 100.00$

$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$
 $\phi_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir, 1} * n_{s1} = 157.0796$
 No stirrups, $n_{s1} = 2.00$
 $h_1 = 200.00$
 $\phi_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir, 2} * n_{s2} = 100.531$
 No stirrups, $n_{s2} = 2.00$
 $h_2 = 100.00$

$A_{sec} = 40000.00$
 $s_1 = 100.00$
 $s_2 = 150.00$

$f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $\phi_c = 0.00228783$
 $\phi_c = \text{confinement factor} = 1.02878$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

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

$\phi_{o/lou, \min} = \phi_b / \phi_d = 1.00$

$\phi_{s1} = 0.4 * \phi_{su1, \text{nominal}} ((5.5), TBDY) = 0.032$

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

For calculation of $\phi_{su1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $f_{sy1} = f_{s1} / 1.2$, from table 5.1, TBDY.

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

with $f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 694.45$

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

$y_2 = 0.0025$
 $sh_2 = 0.008$

```

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) = 0.93591561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
    1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
    2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
    v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 * M_{Rc}$

--->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$\mu = M_{Rc}$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{ColO} = 262044.453$

$k_n l = 1$ (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)

$M/V_d = 2.00$

$\mu = 2.9879866E-010$

$V_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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, $V_{r2} = 262044.453$

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

$V_{Col0} = 262044.453$

$knl = 1$ (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)

$M / Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$bw = 200.00$

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

At local axis: 2

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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $= 1.00$

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

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

Consequently:

Jacket

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

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 = 15.00
 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 ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.2562E+008
 Shear Force, V2 = -2372.544
 Shear Force, V3 = -4.1216227E-010
 Axial Force, F = -952838.426
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Asl_t = 1476.549
 -Compression: Asl_c = 2293.363
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten} = 1476.549
 -Compression: Asl_{com} = 1476.549
 -Middle: Asl_{mid} = 816.8141
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten,jacket} = 1014.734
 -Compression: Asl_{com,jacket} = 1014.734
 -Middle: Asl_{mid,jacket} = 508.938
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten,core} = 461.8141
 -Compression: Asl_{com,core} = 461.8141
 -Middle: Asl_{mid,core} = 307.8761
 Mean Diameter of Tension Reinforcement, DbL = 17.33333

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.07639787$
 $u = y + p = 0.07639787$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.07534453$ ((4.29), Biskinis Phd))
 $M_y = 9.4932E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 6000.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.5199E+012$
 $factor = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 952838.426$
 $E_c * I_g = E_c_{jacket} * I_{g,jacket} + E_c_{core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 4.0448288E-005$
 with $f_y = 555.56$
 $d = 166.00$

$y = 0.58629312$
 $A = 0.16521104$
 $B = 0.12006404$
 with $pt = 0.0095295$
 $pc = 0.04447435$
 $pv = 0.02460283$
 $N = 952838.426$
 $b = 200.00$
 $" = 0.20481928$
 $y_{comp} = 1.8654349E-005$
 with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.71046623$
 $A = 0.04832572$
 $B = 0.06840454$
 with $Es = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.00105334$

with:

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

shear control ratio $V_y E / V_{Col} E = 0.43225659$

$d = d_{external} = 166.00$

$s = s_{external} = 150.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.0095295$

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: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00167552$

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

$h_2 = 100.00$

$s_2 = 150.00$

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.

$NUD = 952838.426$

$A_g = 40000.00$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section_area = 33.00$

$f_{yIE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} =$

555.56

$f_{yTE} = (f_{y,ext_Trans_Reinf} \cdot Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} =$

555.56

$pI = Area_{Tot_Long_Rein} / (b \cdot d) = 0.11355154$

$b = 200.00$

$d = 166.00$

$f_{cE} = 33.00$

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

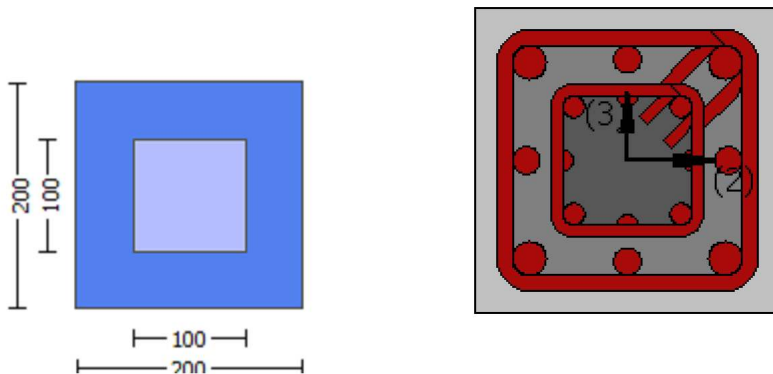
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)



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

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of γ 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, $c = 15.00$
 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, $M_a = -2.2562E+008$
 Shear Force, $V_a = -2372.544$
 EDGE -B-
 Bending Moment, $M_b = -573480.362$
 Shear Force, $V_b = 2372.544$
 BOTH EDGES
 Axial Force, $F = -952838.426$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{st} = 0.00$
 -Compression: $A_{sc} = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{st,ten} = 1476.549$
 -Compression: $A_{st,com} = 1476.549$
 -Middle: $A_{st,mid} = 816.8141$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.33333$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 165078.538$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI0} = 165078.538$
 $V_{CoI} = 235826.482$
 $k_n = 0.70$
 displacement_ductility_demand = 8.27565

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

= 1 (normal-weight concrete)
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 573480.362$
 $V_u = 2372.544$
 $d = 0.8 \cdot h = 160.00$
 $N_u = 952838.426$
 $A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$

$f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From $(11-11)$, ACI 440: $V_s + V_f \leq 106288.613$
 $b_w = 200.00$

displacement ductility demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 0.03117626$
 $y = (M_y * L_s / 3) / E_{eff} = 0.00376723 ((4.29), \text{Biskinis Phd})$
 $M_y = 9.4932E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 2.5199E+012$
 $\text{factor} = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$
 $N = 952838.426$
 $E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 4.0448288E-005$
 with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58629312$
 $A = 0.16521104$
 $B = 0.12006404$
 with $p_t = 0.04447435$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
 $N = 952838.426$
 $b = 200.00$
 $\rho = 0.20481928$
 $y_{\text{comp}} = 1.8654349E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.71046623$
 $A = 0.04832572$
 $B = 0.06840454$
 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

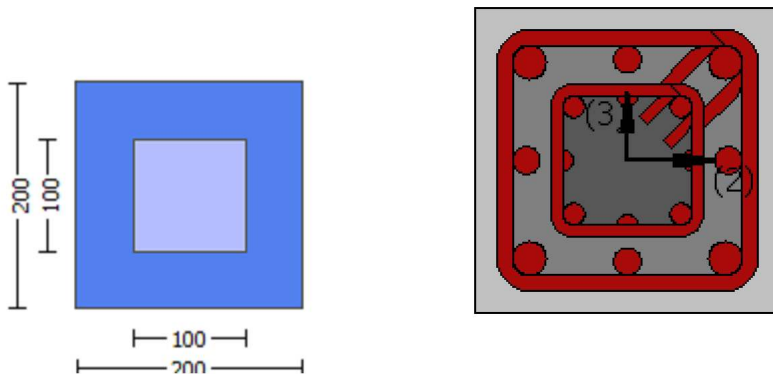
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $c = 15.00$
 Mean Confinement Factor overall section = 1.02878
 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, $V_a = -1.1598602E-029$
 EDGE -B-
 Shear Force, $V_b = 1.1598602E-029$
 BOTH EDGES
 Axial Force, $F = -954435.753$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1476.549$
 -Compression: $As_{c,com} = 1476.549$
 -Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.6451905E-005$
 $\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 ϕ_o (5A.5, TBDY) = 0.002
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \max(\phi_u, \phi_o) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_u = 0.01061002$

$w_e (5.4c) = 0.03159521$
 $ase ((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min \cdot Fywe = \text{Min}(psh, x \cdot Fywe, psh, y \cdot Fywe) = 6.61776$

$psh, x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$psh, y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$

$s1 = 100.00$

$s2 = 150.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$

$c = \text{confinement factor} = 1.02878$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

$su1 = 0.4 \cdot esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

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

with $fs1 = (fs_{jacket} \cdot A_{sl, ten, jacket} + fs_{core} \cdot A_{sl, ten, core}) / A_{sl, ten} = 694.45$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

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

$su2 = 0.4 \cdot esu2_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu2_nominal = 0.08$,

For calculation of $es_{u2_nominal}$ 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

$lo/lou_{min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, 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 $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.94983$
 $cc \text{ (5A.5, TBDY)} = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu \text{ (4.10)} = 0.7393216$
 $M_{Rc} \text{ (4.17)} = 1.6991E+008$

--->

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, 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00


```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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, ec
---->
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 not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi (5A.5, TBDY) = 0.002$
 Final value of ϕ : $\phi^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_u = 0.01061002$
 $\phi_w (5.4c) = 0.03159521$
 $\phi_{se} ((5.4d), TBDY) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.15755208$
 $\phi_{se1} = 0.15755208$
 $b_{o_1} = 160.00$
 $h_{o_1} = 160.00$
 $b_{i2_1} = 102400.00$
 $\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.15755208$
 $b_{o_2} = 92.00$
 $h_{o_2} = 92.00$
 $b_{i2_2} = 33856.00$
 $\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.61776$

$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$
 $\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$
 $\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$A_{sec} = 40000.00$
 $s_1 = 100.00$
 $s_2 = 150.00$

$f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $\phi_c = 0.00228783$
 $\phi_c = \text{confinement factor} = 1.02878$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

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

$\phi_o / \phi_{ou, \min} = \phi_b / \phi_d = 1.00$

$su_1 = 0.4 * \phi_{su1_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\phi_{su1_nominal} = 0.08$,

For calculation of $\phi_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $f_{sy1} = f_{s1} / 1.2$, from table 5.1, TBDY.

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

with $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 694.45$

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

$y_2 = 0.0025$
 $sh_2 = 0.008$

```

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 * M_{Rc}$

--->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$\mu_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 8.6451905E-005$

$\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

α (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

w_e (5.4c) = 0.03159521

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$

$a_{se1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.61776$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.61776$

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

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

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 $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, 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

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

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

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 $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, 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

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

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

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

```

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{Col0} = 262044.453$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$\nu_u = 1.1598602E-029$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$

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

$V_{Col0} = 262044.453$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$\nu_u = 1.1598602E-029$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.875
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, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$
Existing Column
New material: Steel Strength, $f_s = 1.25 * f_{sm} = 694.45$

External Height, $H = 200.00$
External Width, $W = 200.00$
Internal Height, $H = 100.00$
Internal Width, $W = 100.00$
Cover Thickness, $c = 15.00$
Mean Confinement Factor overall section = 1.02878
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: 2
EDGE -A-
Shear Force, $V_a = 7.1018611E-046$
EDGE -B-

Shear Force, $V_b = -7.1018611E-046$

BOTH EDGES

Axial Force, $F = -954435.753$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3769.911$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{ten} = 1476.549$

-Compression: $As_{com} = 1476.549$

-Middle: $As_{mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$

with

$M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$

$\mu_{u1+} = 1.6991E+008$, 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

$\mu_{u1-} = 1.6991E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$

$\mu_{u2+} = 1.6991E+008$, 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

$\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

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

$\phi_u = 8.6451905E-005$

$M_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01061002$

we (5.4c) = 0.03159521

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$

$ase1 = 0.15755208$

$bo_1 = 160.00$

$ho_1 = 160.00$

$bi2_1 = 102400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.15755208$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi2_2 = 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.61776$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$

$ps1$ (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) = $(Ash2 * h2 / s2) / A_{sec} = 0.00167552$

Ash2 = Astir_2*ns_2 = 100.531
 No stirups, ns_2 = 2.00
 h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
 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 = 0.00167552
 Ash2 = Astir_2*ns_2 = 100.531
 No stirups, ns_2 = 2.00
 h2 = 100.00

Asec = 40000.00
 s1 = 100.00
 s2 = 150.00
 fywe1 = 694.45
 fywe2 = 694.45
 fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783
 c = confinement factor = 1.02878

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.
 $y_1, sh_1, ft_1, f_{y1}$ , 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  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$ 
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.93591561$ 
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.93591561$ 
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.51774055$ 
and confined core properties:
 $b = 160.00$ 
 $d = 146.00$ 
 $d' = 14.00$ 
 $f_{cc} \text{ (5A.2, TBDY)} = 33.94983$ 
 $cc \text{ (5A.5, TBDY)} = 0.00228783$ 
 $c = \text{confinement factor} = 1.02878$ 
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 1.33015$ 
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 1.33015$ 
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.73582989$ 
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
 $v < v_{s,c}$  - 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
---->
 $\epsilon_{cu} \text{ (4.10)} = 0.7393216$ 
 $M_{Rc} \text{ (4.17)} = 1.6991E+008$ 
---->
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  $b \cdot d$ 
-  $f_{cc}, cc$  parameters of confined concrete,  $f_{cc}, cc$ , 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 not satisfied
---->
 $v^* < v^*_{c,y1}$  - RHS eq.(4.6) is not satisfied
---->
 $\epsilon^*_{cu} \text{ (4.11)} = 0.65248434$ 
 $M_{Ro} \text{ (4.18)} = 1.2423E+008$ 
 $M_{Ro} < 0.8 \cdot M_{Rc}$ 
---->
 $u = \epsilon_{cu} \text{ (unconfined full section)} = 8.6451905E-005$ 
 $\mu = M_{Rc}$ 

```

Calculation of ratio l_b/l_d

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

Calculation of Mu1-

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

$$\mu = 8.6451905E-005$$

$$Mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$v = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.01061002$$

$$\mu_{cc}(5.4c) = 0.03159521$$

$$\text{ase}((5.4d), TBDY) = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.15755208$$

$$\text{ase}_1 = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 6.61776$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 6.61776$$

$$\text{ps}_1(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\text{ps}_2(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 6.61776$$

$$\text{ps}_1(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\text{ps}_2(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \mu_{cc} = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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
--->

```

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $c_u(4.10) = 0.7393216$
 $M_{Rc}(4.17) = 1.6991E+008$
 --->
 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, e_c
 --->
 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 not satisfied
 --->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied
 --->
 $*c_u(4.11) = 0.65248434$
 $M_{Ro}(4.18) = 1.2423E+008$
 $M_{Ro} < 0.8*M_{Rc}$
 --->
 $u = c_u$ (unconfined full section) = $8.6451905E-005$
 $M_u = M_{Rc}$

Calculation of ratio l_b/d

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

Calculation of M_{u2+}

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

$u = 8.6451905E-005$

$M_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

$w_e(5.4c) = 0.03159521$

$a_{se}((5.4d), TBDY) = (a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.15755208$

$a_{se1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 150.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783
c = confinement factor = 1.02878

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,tens,jacket + fs,core*Asl,tens,core)/Asl,tens = 694.45

with Es1 = (Es,jacket*Asl,tens,jacket + Es,core*Asl,tens,core)/Asl,tens = 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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->

```


u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753

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

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01061002

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01061002

we (5.4c) = 0.03159521

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208

ase1 = 0.15755208

bo_1 = 160.00

ho_1 = 160.00

bi2_1 = 102400.00

ase2 = Max(ase1,ase2) = 0.15755208

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776

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 = 0.00167552

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776

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 = 0.00167552

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
 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 $Es_v = (Es_jacket * Asl, \text{mid}, \text{jacket} + Es_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.93591561$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.93591561$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 1.33015$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 1.33015$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

$v < v_{s,c}$ - 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

--->

ϕ_{cu} (4.10) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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
- $N, \epsilon_1, \epsilon_2, \nu$ normalised to b_o*d_o , instead of $b*d$
- f_{cc}, ϵ_{cc} parameters of confined concrete, f_{cc}, ϵ_{cc} used in lieu of f_c, ϵ_{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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

ϕ^*_{cu} (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8*M_{Rc}$

--->

$\phi_u = \phi_{cu}$ (unconfined full section) = 8.6451905E-005

$\mu_u = M_{Rc}$

Calculation of ratio I_b/I_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{ColO} = 262044.453$

$k_{nl} = 1$ (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).

$\phi = 1$ (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)

$M/V_d = 2.00$

$\mu_u = 2.9879866E-010$

$V_u = 7.1018611E-046$

$d = 0.8*h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 122116.319$
 $bw = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 262044.453$
 $knl = 1$ (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)
 $M/Vd = 2.00$
 $M_u = 2.9879866E-010$
 $V_u = 7.1018611E-046$
 $d = 0.8 * h = 160.00$
 $N_u = 954435.753$
 $A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 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: 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, $c = 15.00$
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 ($l_b/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = 5.8770792E-007$
Shear Force, $V_2 = 2372.544$
Shear Force, $V_3 = 4.1216227E-010$
Axial Force, $F = -952838.426$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1476.549$
-Compression: $As_{l,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 1014.734$
-Compression: $As_{l,com,jacket} = 1014.734$
-Middle: $As_{l,mid,jacket} = 508.938$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 461.8141$
-Compression: $As_{l,com,core} = 461.8141$
-Middle: $As_{l,mid,core} = 307.8761$
Mean Diameter of Tension Reinforcement, $Db_L = 17.33333$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.01988947$
 $u = \gamma + \rho = 0.01988947$

- Calculation of γ -

$y = (M_y * L_s / 3) / E_{eff} = 0.01883613 \text{ ((4.29), Biskinis Phd)}$
 $M_y = 9.4932E+007$
 $L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 2.5199E+012$
 $\text{factor} = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_{c'}^{\text{jacket}} * A_{\text{jacket}} + f_{c'}^{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$
 $N = 952838.426$
 $E_c * I_g = E_{c_jacket} * I_{g_jacket} + E_{c_core} * I_{g_core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 4.0448288E-005$
 with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58629312$
 $A = 0.16521104$
 $B = 0.12006404$
 with $p_t = 0.0095295$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
 $N = 952838.426$
 $b = 200.00$
 $\alpha = 0.20481928$
 $y_{\text{comp}} = 1.8654349E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.71046623$
 $A = 0.04832572$
 $B = 0.06840454$
 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: $p = 0.00105334$

with:

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

shear control ratio $V_y/E/V_{col0E} = 0.43225659$

$d = d_{\text{external}} = 166.00$

$s = s_{\text{external}} = 150.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.0095295$

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: $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00167552$

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

$h_2 = 100.00$

$s_2 = 150.00$

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

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

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

For the normalisation f_s of jacket is used.

$N_{UD} = 952838.426$

$A_g = 40000.00$

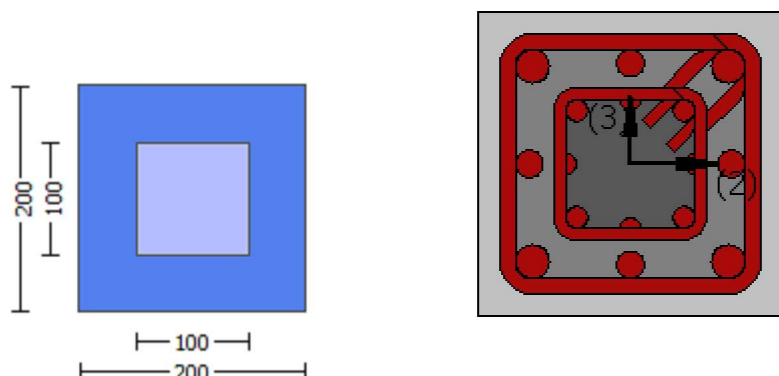
$f_{cE} = (f_{c_jacket} * A_{\text{jacket}} + f_{c_core} * A_{\text{core}}) / \text{section_area} = 33.00$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$
 $f_{tE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 555.56$
 $\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.11355154$
 $b = 200.00$
 $d = 166.00$
 $f_{cE} = 33.00$

 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 V_{Rd}
 Edge: End
 Local Axis: (3)



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

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
 Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$
New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of γ 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, $c = 15.00$
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, $M_a = -3.7448736E-006$
Shear Force, $V_a = -4.1216227E-010$
EDGE -B-
Bending Moment, $M_b = 5.8770792E-007$
Shear Force, $V_b = 4.1216227E-010$
BOTH EDGES
Axial Force, $F = -952838.426$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{l,ten} = 1476.549$
-Compression: $As_{l,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.33333$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 235826.482$
 V_n ((10.3), ASCE 41-17) = $k_n l \cdot V_{CoI} = 235826.482$
 $V_{CoI} = 235826.482$
 $k_n l = 1.00$
displacement_ductility_demand = $3.2973624E-014$

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)
 $M/Vd = 2.00$
 $\mu_u = 5.8770792E-007$
 $V_u = 4.1216227E-010$
 $d = 0.8 \cdot h = 160.00$
 $N_u = 952838.426$
 $A_g = 40000.00$
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:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
From (11-11), ACI 440: $V_s + V_f \leq 106288.613$
 $b_w = 200.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation $\theta = 6.2182456E-016$
 $y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.01883613 ((4.29), \text{Biskinis Phd})$
 $M_y = 9.4932E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 2.5199E+012$
factor = 0.70
 $A_g = 40000.00$
Mean concrete strength: $f'_c = (f'_{c_jacket} \cdot \text{Area}_{jacket} + f'_{c_core} \cdot \text{Area}_{core}) / \text{Area}_{section} = 33.00$
 $N = 952838.426$
 $E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$
 $y_{\text{ten}} = 4.0448288E-005$
with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58629312$
 $A = 0.16521104$
 $B = 0.12006404$
with $p_t = 0.04447435$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
 $N = 952838.426$
 $b = 200.00$
 $\rho = 0.20481928$
 $y_{\text{comp}} = 1.8654349E-005$
with $f_c = 33.00$
 $E_c = 26999.444$

$y = 0.71046623$
 $A = 0.04832572$
 $B = 0.06840454$
 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

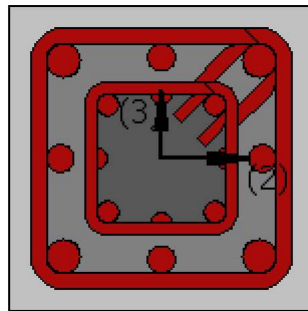
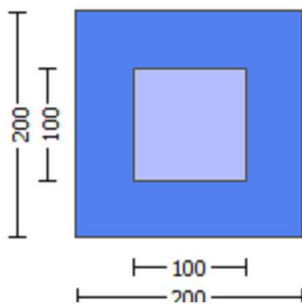
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $c = 15.00$
 Mean Confinement Factor overall section = 1.02878
 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, $V_a = -1.1598602E-029$
 EDGE -B-
 Shear Force, $V_b = 1.1598602E-029$
 BOTH EDGES
 Axial Force, $F = -954435.753$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{sl,t} = 0.00$
 -Compression: $A_{sl,c} = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1476.549$
 -Compression: $A_{sl,com} = 1476.549$
 -Middle: $A_{sl,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

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

$$\phi_u = 8.6451905E-005$$

$$\mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

$$\phi_{0.5A} (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{we} (5.4c) = 0.03159521$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{ase1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 833.34$$

$$f_{y1} = 694.45$$

$$su_1 = 0.032$$

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

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

```

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/lc)^ 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/lc)^ 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/lc = 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/lc)^ 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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

$psh_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,
considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $e_{suv,nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered
characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $f_{sv} = (f_{sj,jacket} * A_{sl,mid,jacket} + f_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
with $E_{sv} = (E_{sj,jacket} * A_{sl,mid,jacket} + E_{s,mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (f_{s1}/f_c) = 0.93591561$
 $2 = A_{sl,com} / (b * d) * (f_{s2}/f_c) = 0.93591561$
 $v = A_{sl,mid} / (b * d) * (f_{sv}/f_c) = 0.51774055$
and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = A_{sl,ten} / (b * d) * (f_{s1}/f_c) = 1.33015$
 $2 = A_{sl,com} / (b * d) * (f_{s2}/f_c) = 1.33015$
 $v = A_{sl,mid} / (b * d) * (f_{sv}/f_c) = 0.73582989$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - 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
--->
 $c_u (4.10) = 0.7393216$
 $M_{Rc} (4.17) = 1.6991E+008$
--->
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} , 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 not satisfied
--->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied
--->
 $*c_u (4.11) = 0.65248434$
 $M_{Ro} (4.18) = 1.2423E+008$
 $M_{Ro} < 0.8 * M_{Rc}$
--->
 $u = c_u$ (unconfined full section) = $8.6451905E-005$
 $M_u = M_{Rc}$

Calculation of ratio l_b/d

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

Calculation of Mu_2

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

$$u = 8.6451905E-005$$

$$Mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$v = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \phi_u = \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{ue} \text{ (5.4c)} = 0.03159521$$

$$\phi_{se} \text{ ((5.4d), TBDY)} = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{se1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.61776$$

$$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$\phi_c = \text{confinement factor} = 1.02878$$

```

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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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 not satisfied

---->

$v^* < v^* c, y1$ - RHS eq.(4.6) is not satisfied

---->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 * M_{Rc}$

---->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$M_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of M_{u2} -

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

$u = 8.6451905E-005$

$M_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

c_o (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

w_e (5.4c) = 0.03159521

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$

```

ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 150.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

From ((5.A5), TBDY), TBDY: cc = 0.00228783
c = confinement factor = 1.02878

```

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 $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 0.93591561$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 0.93591561$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1 / fc) = 1.33015$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2 / fc) = 1.33015$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv / fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - 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
 --->
 $cu (4.10) = 0.7393216$
 $MRC (4.17) = 1.6991E+008$
 --->
 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
 --->
 $v^* < v^*_{s,y2}$ - 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 not satisfied

```

---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 262044.453
-----
Calculation of Shear Strength at edge 1, Vr1 = 262044.453
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO
VColO = 262044.453
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 = 3.6564195E-010
Vu = 1.1598602E-029
d = 0.8*h = 160.00
Nu = 954435.753
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 = 150.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.875
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 = 262044.453
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VColO
VColO = 262044.453
knl = 1 (zero step-static loading)
-----
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----
= 1 (normal-weight concrete)

```

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

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$\nu_u = 1.1598602E-029$

$d = 0.8 \cdot h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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, $c = 15.00$
Mean Confinement Factor overall section = 1.02878
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, $V_a = 7.1018611E-046$
EDGE -B-
Shear Force, $V_b = -7.1018611E-046$
BOTH EDGES
Axial Force, $F = -954435.753$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1476.549$
-Compression: $As_{c,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.6451905E-005$
 $\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\alpha_1 = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha_1) = 0.01061002$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.01061002$

$w_e(5.4c) = 0.03159521$
 $ase((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min \cdot Fywe = \text{Min}(psh, x \cdot Fywe, psh, y \cdot Fywe) = 6.61776$

$psh, x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1(\text{external}) = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$psh, y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1(\text{external}) = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$

$s1 = 100.00$

$s2 = 150.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$

$c = \text{confinement factor} = 1.02878$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

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

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

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

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

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

For calculation of $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

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

$lo/lo_{u,min} = lb/ld = 1.00$
 $suv = 0.4 \cdot es_{u_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{u_nominal} = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, 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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu (4.10) = 0.7393216$
 $M_{Rc} (4.17) = 1.6991E+008$

--->

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, f_{cc}, cc , used in lieu of fc, 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00

```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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, ec
---->
Subcase: Rupture of tension steel
---->
v* < v*sy2 - 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $co(5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01061002$
 $w_e(5.4c) = 0.03159521$
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.61776$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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

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

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

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

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

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

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

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/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) = 0.93591561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
    1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
    2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
    v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 * M_{Rc}$

--->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$\mu_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 8.6451905E-005$

$\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

α (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

w_e (5.4c) = 0.03159521

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$

$a_{se1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.61776$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.61776$

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

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*cy2 - LHS eq.(4.6) is not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{Col0} = 262044.453$

$k_{nl} = 1$ (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)

$M/Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$

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

$V_{Col0} = 262044.453$

$k_{nl} = 1$ (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)

$M/Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.875
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, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Height, H = 200.00
External Width, W = 200.00
Internal Height, H = 100.00
Internal Width, W = 100.00
Cover Thickness, c = 15.00
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 (lb/ld >= 1)
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -573480.362
Shear Force, V2 = 2372.544
Shear Force, V3 = 4.1216227E-010
Axial Force, F = -952838.426
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3769.911
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 1476.549
-Compression: Asl,com = 1476.549
-Middle: Asl,mid = 816.8141
Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,jacket} = 1014.734$

-Compression: $Asl_{com,jacket} = 1014.734$

-Middle: $Asl_{mid,jacket} = 508.938$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,core} = 461.8141$

-Compression: $Asl_{com,core} = 461.8141$

-Middle: $Asl_{mid,core} = 307.8761$

Mean Diameter of Tension Reinforcement, $DbL = 17.33333$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00482056$

$u = y + p = 0.00482056$

- Calculation of y -

$y = (My * Ls / 3) / Eleff = 0.00376723$ ((4.29), Biskinis Phd))

$My = 9.4932E+007$

$Ls = M/V$ (with $Ls > 0.1 * L$ and $Ls < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $Eleff = factor * Ec * Ig = 2.5199E+012$

factor = 0.70

$Ag = 40000.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 952838.426$

$Ec * Ig = Ec_{jacket} * Ig_{jacket} + Ec_{core} * Ig_{core} = 3.5999E+012$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{ten} = 4.0448288E-005$

with $fy = 555.56$

$d = 166.00$

$y = 0.58629312$

$A = 0.16521104$

$B = 0.12006404$

with $pt = 0.0095295$

$pc = 0.04447435$

$pv = 0.02460283$

$N = 952838.426$

$b = 200.00$

$" = 0.20481928$

$y_{comp} = 1.8654349E-005$

with $fc = 33.00$

$Ec = 26999.444$

$y = 0.71046623$

$A = 0.04832572$

$B = 0.06840454$

with $Es = 200000.00$

Calculation of ratio lb/ld

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

- Calculation of p -

From table 10-8: $p = 0.00105334$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/ld \geq 1$
shear control ratio $VyE/VCoIE = 0.43225659$

```

d = d_external = 166.00
s = s_external = 150.00
t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.0095295
jacket: s1 = Av1*h1/(s1*Ag) = 0.00785398
        Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
        h1 = 200.00
        s1 = 100.00
core: s2 = Av2*h2/(s2*Ag) = 0.00167552
        Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
        h2 = 100.00
        s2 = 150.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 952838.426
Ag = 40000.00
fcE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fyIE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein =
555.56
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein =
555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.11355154
b = 200.00
d = 166.00
fcE = 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

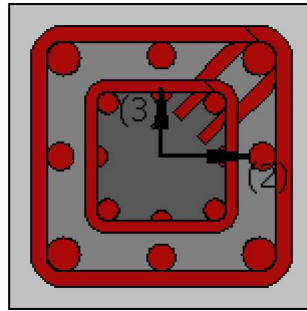
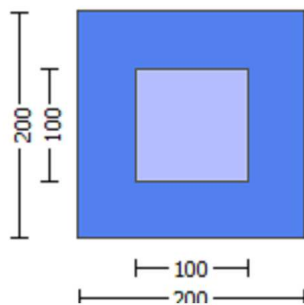
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

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 γ 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, $c = 15.00$

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, $M_a = -2.6971E+008$

Shear Force, $V_a = -1653.244$

EDGE -B-
 Bending Moment, Mb = -448047.023
 Shear Force, Vb = 1653.244
 BOTH EDGES
 Axial Force, F = -952465.534
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 1476.549
 -Compression: Aslc = 2293.363
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1476.549
 -Compression: Asl,com = 1476.549
 -Middle: Asl,mid = 816.8141
 Mean Diameter of Tension Reinforcement, DbL,ten = 17.33333

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 171046.073
 Vn ((10.3), ASCE 41-17) = knl*VCol0 = 171046.073
 VCol = 171046.073
 knl = 1.00
 displacement_ductility_demand = 1.23043

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

 = 1 (normal-weight concrete)
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 4.00
 Mu = 2.6971E+008
 Vu = 1653.244
 d = 0.8*h = 160.00
 Nu = 952465.534
 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 = 150.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.875
 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 / y

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

 From analysis, chord rotation = 0.09271255
 y = (My*Ls/3)/Eleff = 0.07534979 ((4.29),Biskinis Phd))
 My = 9.4939E+007
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 6000.00
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.5199E+012

factor = 0.70
Ag = 40000.00
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$
N = 952465.534
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.0444941E-005$
with $f_y = 555.56$
d = 166.00
y = 0.58625889
A = 0.16519083
B = 0.12004383
with $p_t = 0.04447435$
pc = 0.04447435
pv = 0.02460283
N = 952465.534
b = 200.00
" = 0.20481928
 $y_{comp} = 1.8657650E-005$
with $fc = 33.00$
Ec = 26999.444
y = 0.71034051
A = 0.04835124
B = 0.06840454
with $E_s = 200000.00$

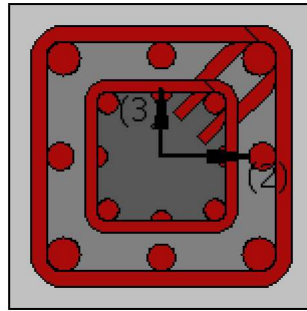
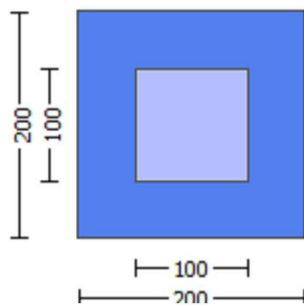
Calculation of ratio I_b/I_d

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 (ϕ_r)
Edge: Start
Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

New material of 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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878

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, $V_a = -1.1598602E-029$

EDGE -B-

Shear Force, $V_b = 1.1598602E-029$

BOTH EDGES

Axial Force, $F = -954435.753$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1476.549$
 -Compression: $As_{l,com} = 1476.549$
 -Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.6991\text{E}+008$
 $\mu_{u1+} = 1.6991\text{E}+008$, 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
 $\mu_{u1-} = 1.6991\text{E}+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.6991\text{E}+008$
 $\mu_{u2+} = 1.6991\text{E}+008$, 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
 $\mu_{u2-} = 1.6991\text{E}+008$, 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 μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.6451905\text{E}-005$
 $\mu_u = 1.6991\text{E}+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi_c \text{ (5A.5, TBDY)} = 0.002$
 Final value of ϕ_{cu} : $\phi_{cu} = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_c) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_{cu} = 0.01061002$
 $\phi_{we} \text{ (5.4c)} = 0.03159521$
 $\phi_{ase} \text{ ((5.4d), TBDY)} = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$
 $\phi_{ase1} = 0.15755208$
 $b_{o_1} = 160.00$
 $h_{o_1} = 160.00$
 $b_{i2_1} = 102400.00$
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$
 $b_{o_2} = 92.00$
 $h_{o_2} = 92.00$
 $b_{i2_2} = 33856.00$
 $\phi_{psh,min} * F_{ywe} = \text{Min}(\phi_{psh,x} * F_{ywe}, \phi_{psh,y} * F_{ywe}) = 6.61776$

$\phi_{psh,x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{psh2} * F_{ywe2} = 6.61776$
 $\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*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 not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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

```

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

$$\phi_u = 8.6451905E-005$$

$$\mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

$$\phi_{0.5A} (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{we} (5.4c) = 0.03159521$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{ase1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 833.34$$

$$f_{y1} = 694.45$$

$$su_1 = 0.032$$

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

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

```

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```


$psh_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

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

$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$, 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
 $Shear_factor = 1.00$

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

$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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 $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$, 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
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
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, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$
with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.93591561$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.93591561$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.51774055$
and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 1.33015$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 1.33015$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.73582989$
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
 $v < v_{s,c}$ - 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
--->
 $cu (4.10) = 0.7393216$
 $MRc (4.17) = 1.6991E+008$
--->
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 not satisfied
--->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied
--->
 $*cu (4.11) = 0.65248434$
 $MRo (4.18) = 1.2423E+008$
 $MRo < 0.8 * MRc$
--->
 $u = cu$ (unconfined full section) = $8.6451905E-005$
 $Mu = MRc$

Calculation of ratio l_b/d

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

Calculation of μ_u

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

$$\mu_u = 8.6451905E-005$$

$$\mu_u = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \omega) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu_u = 0.01061002$$

$$\omega (5.4c) = 0.03159521$$

$$\omega (5.4d), \text{TB DY} = (\omega_1 * A_{ext} + \omega_2 * A_{int}) / A_{sec} = 0.15755208$$

$$\omega_1 = 0.15755208$$

$$b_{o1} = 160.00$$

$$h_{o1} = 160.00$$

$$b_{i1} = 102400.00$$

$$\omega_2 = \text{Max}(\omega_1, \omega_2) = 0.15755208$$

$$b_{o2} = 92.00$$

$$h_{o2} = 92.00$$

$$b_{i2} = 33856.00$$

$$\mu_{sh, \min} * F_{ywe} = \text{Min}(\mu_{sh, x} * F_{ywe}, \mu_{sh, y} * F_{ywe}) = 6.61776$$

$$\mu_{sh, x} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 6.61776$$

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

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 200.00$$

$$\mu_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 100.00$$

$$\mu_{sh, y} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 6.61776$$

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

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 200.00$$

$$\mu_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \omega_c = 0.00228783$$

$$\omega_c = \text{confinement factor} = 1.02878$$

```

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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

---->

ϵ_{cu} (4.10) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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} , ϵ_{cc} , used in lieu of f_c , ϵ_{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 not satisfied

---->

$v^* < v^* c, y_1$ - RHS eq.(4.6) is not satisfied

---->

ϵ^*_{cu} (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 \cdot M_{Rc}$

---->

$u = \epsilon_{cu}$ (unconfined full section) = 8.6451905E-005

$\mu = M_{Rc}$

Calculation of ratio I_b/I_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{Co10} = 262044.453$

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

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

 $= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$V_u = 1.1598602E-029$

$d = 0.8 \cdot h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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 = 262044.453

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

VCol0 = 262044.453

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 = 3.6564195E-010

Vu = 1.1598602E-029

d = 0.8*h = 160.00

Nu = 954435.753

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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, $\gamma = 1.00$

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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878

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, $V_a = 7.1018611E-046$

EDGE -B-

Shear Force, $V_b = -7.1018611E-046$

BOTH EDGES

Axial Force, $F = -954435.753$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3769.911$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1476.549$

-Compression: $As_{l,com} = 1476.549$

-Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6991E+008$

$M_{u1+} = 1.6991E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction

which is defined for the static loading combination

$Mu1- = 1.6991E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu2+, Mu2-) = 1.6991E+008$

$Mu2+ = 1.6991E+008$, 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

$Mu2- = 1.6991E+008$, 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 $Mu1+$

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

$\phi_u = 8.6451905E-005$

$M_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01061002$

$\phi_{we} (5.4c) = 0.03159521$

$\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$

$\phi_{ase1} = 0.15755208$

$\phi_{bo_1} = 160.00$

$\phi_{ho_1} = 160.00$

$\phi_{bi2_1} = 102400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$

$\phi_{bo_2} = 92.00$

$\phi_{ho_2} = 92.00$

$\phi_{bi2_2} = 33856.00$

$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$

$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$

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

$\phi_{Ash1} = \phi_{Astir_1} * n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h1 = 200.00$

$\phi_{ps2} \text{ (internal)} = (\phi_{Ash2} * h2 / s2) / A_{sec} = 0.00167552$

$\phi_{Ash2} = \phi_{Astir_2} * n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h2 = 100.00$

$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$

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

$\phi_{Ash1} = \phi_{Astir_1} * n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h1 = 200.00$

$\phi_{ps2} \text{ (internal)} = (\phi_{Ash2} * h2 / s2) / A_{sec} = 0.00167552$

$\phi_{Ash2} = \phi_{Astir_2} * n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h2 = 100.00$

$A_{sec} = 40000.00$

$s1 = 100.00$

$s2 = 150.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
 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 $Es_v = (Es_jacket * Asl, \text{mid}, \text{jacket} + Es_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.93591561$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.93591561$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 1.33015$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 1.33015$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

```

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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002

```

```

we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00

```

```

s1 = 100.00

```

```

s2 = 150.00

```

```

fywe1 = 694.45

```

```

fywe2 = 694.45

```

```

fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00228783

```

```

c = confinement factor = 1.02878

```

```

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 $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

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

$lo/lou_{min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

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

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

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc \text{ (5A.2, TBDY)} = 33.94983$
 $cc \text{ (5A.5, TBDY)} = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu \text{ (4.10)} = 0.7393216$
 $MRC \text{ (4.17)} = 1.6991E+008$

--->

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

--->

$v^* < v^*_{s,y2}$ - 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00

```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $co(5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01061002$
 $w_e(5.4c) = 0.03159521$
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.61776$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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

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

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

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

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

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

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

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/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/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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

*cu (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

M_{Ro} < 0.8*M_{Rc}

--->

u = cu (unconfined full section) = 8.6451905E-005

Mu = M_{Rc}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

$V_{r1} = V_{CoI}$ ((10.3), ASCE 41-17) = knl*V_{CoI0}

V_{CoI0} = 262044.453

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/V_d = 2.00

Mu = 2.9879866E-010

Vu = 7.1018611E-046

d = 0.8*h = 160.00

Nu = 954435.753

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 = 150.00

V_{s2} is multiplied by Col2 = 0.00

s/d = 1.875

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, $V_{r2} = 262044.453$

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

$V_{Col0} = 262044.453$

$knl = 1$ (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)

$M / Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\mu_v = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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: 2

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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $= 1.00$

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

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

Consequently:

Jacket

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

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 = 15.00
 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 ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, M = -4.3546420E-006
 Shear Force, V2 = -1653.244
 Shear Force, V3 = -5.2953879E-010
 Axial Force, F = -952465.534
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Asl_t = 1476.549
 -Compression: Asl_c = 2293.363
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten} = 1476.549
 -Compression: Asl_{com} = 1476.549
 -Middle: Asl_{mid} = 816.8141
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten,jacket} = 1014.734
 -Compression: Asl_{com,jacket} = 1014.734
 -Middle: Asl_{mid,jacket} = 508.938
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten,core} = 461.8141
 -Compression: Asl_{com,core} = 461.8141
 -Middle: Asl_{mid,core} = 307.8761
 Mean Diameter of Tension Reinforcement, DbL = 17.33333

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.02235465$
 $u = y + p = 0.02235465$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.01883745$ ((4.29), Biskinis Phd))
 $M_y = 9.4939E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.5199E+012$
 $factor = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 952465.534$
 $E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 4.0444941E-005$
 with $f_y = 555.56$
 $d = 166.00$

$y = 0.58625889$
 $A = 0.16519083$
 $B = 0.12004383$
 with $pt = 0.0095295$
 $pc = 0.04447435$
 $pv = 0.02460283$
 $N = 952465.534$
 $b = 200.00$
 $" = 0.20481928$
 $y_{comp} = 1.8657650E-005$
 with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
 with $Es = 200000.00$

Calculation of ratio I_b/I_d

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

- Calculation of p -

From table 10-8: $p = 0.0035172$

with:

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

shear control ratio $V_y E / V_{Col} E = 0.43225659$

$d = d_{external} = 166.00$

$s = s_{external} = 150.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.0095295$

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: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00167552$

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

$h_2 = 100.00$

$s_2 = 150.00$

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.

$NUD = 952465.534$

$A_g = 40000.00$

$f_{cE} = (f_{c,jacket} \cdot Area_{jacket} + f_{c,core} \cdot Area_{core}) / section_area = 33.00$

$f_{yIE} = (f_{y,ext_Long_Reinf} \cdot Area_{ext_Long_Reinf} + f_{y,int_Long_Reinf} \cdot Area_{int_Long_Reinf}) / Area_{Tot_Long_Rein} = 555.56$

$f_{yTE} = (f_{y,ext_Trans_Reinf} \cdot Area_{ext_Trans_Reinf} + f_{y,int_Trans_Reinf} \cdot Area_{int_Trans_Reinf}) / Area_{Tot_Trans_Rein} = 555.56$

$pI = Area_{Tot_Long_Rein} / (b \cdot d) = 0.11355154$

$b = 200.00$

$d = 166.00$

$f_{cE} = 33.00$

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

At local axis: 2

Integration Section: (a)

Calculation No. 11

column C1, Floor 1

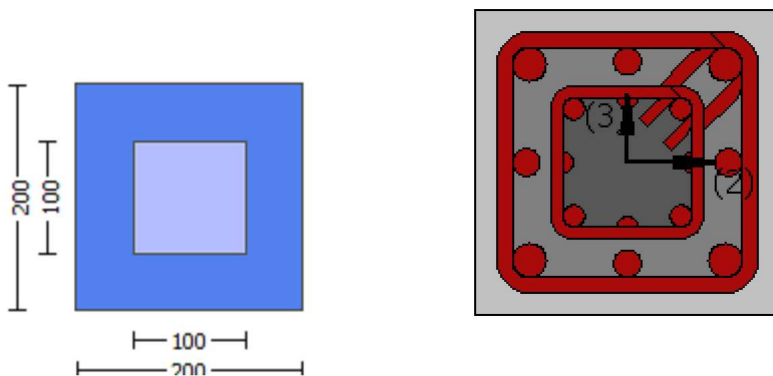
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (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 γ 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, $c = 15.00$
 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, $M_a = -4.3546420E-006$
 Shear Force, $V_a = -5.2953879E-010$
 EDGE -B-
 Bending Moment, $M_b = 7.1301600E-007$
 Shear Force, $V_b = 5.2953879E-010$
 BOTH EDGES
 Axial Force, $F = -952465.534$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 1476.549$
 -Compression: $As_c = 2293.363$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1476.549$
 -Compression: $As_{c,com} = 1476.549$
 -Middle: $As_{mid} = 816.8141$
 Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.33333$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $VR = 1.0 \cdot V_n = 235803.533$
 $V_n ((10.3), ASCE 41-17) = knl \cdot V_{Col0} = 235803.533$
 $V_{Col} = 235803.533$
 $knl = 1.00$
 $displacement_ductility_demand = 9.7033492E-014$

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: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $fc'^{0.5} \leq 8.3$
 MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 4.3546420E-006$
 $V_u = 5.2953879E-010$
 $d = 0.8 \cdot h = 160.00$
 $N_u = 952465.534$
 $A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$

$f_y = 500.00$
 $s = 150.00$
 V_{s2} is multiplied by $\text{Col2} = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), \text{ACI } 440) = 0.00$
 From $(11-11)$, ACI 440: $V_s + V_f \leq 106288.613$
 $b_w = 200.00$

displacement ductility demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 1.8279456 \times 10^{-15}$
 $y = (M_y * L_s / 3) / E_{eff} = 0.01883745 ((4.29), \text{Biskinis Phd})$
 $M_y = 9.4939 \times 10^7$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 2.5199 \times 10^{12}$
 $\text{factor} = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} * \text{Area}_{\text{jacket}} + f_c'_{\text{core}} * \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$
 $N = 952465.534$
 $E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 3.5999 \times 10^{12}$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(\phi_{\text{ten}}, \phi_{\text{com}})$
 $\phi_{\text{ten}} = 4.0444941 \times 10^{-5}$
 with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58625889$
 $A = 0.16519083$
 $B = 0.12004383$
 with $p_t = 0.04447435$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
 $N = 952465.534$
 $b = 200.00$
 $\phi = 0.20481928$
 $\phi_{\text{comp}} = 1.8657650 \times 10^{-5}$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
 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. 12

column C1, Floor 1

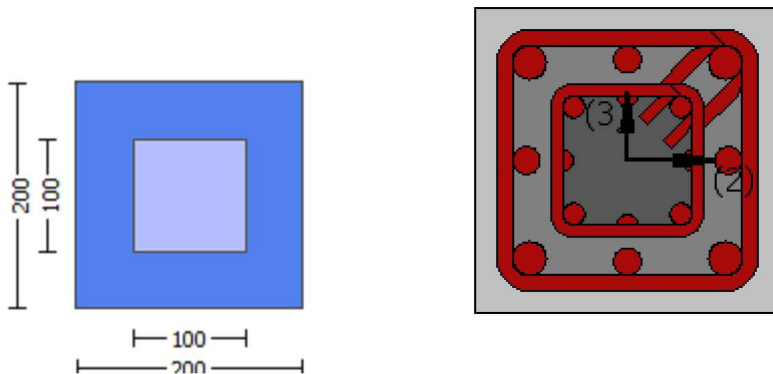
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $c = 15.00$
 Mean Confinement Factor overall section = 1.02878
 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, $V_a = -1.1598602E-029$
 EDGE -B-
 Shear Force, $V_b = 1.1598602E-029$
 BOTH EDGES
 Axial Force, $F = -954435.753$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1476.549$
 -Compression: $As_{c,com} = 1476.549$
 -Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.6451905E-005$
 $\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi_o (5A.5, \text{TBDY}) = 0.002$
 Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \max(\phi_u, \phi_o) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_u = 0.01061002$

```

we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00

```

```

s1 = 100.00

```

```

s2 = 150.00

```

```

fywe1 = 694.45

```

```

fywe2 = 694.45

```

```

fce = 33.00

```

```

From ((5.A5), TBDY), TBDY: cc = 0.00228783

```

```

c = confinement factor = 1.02878

```

```

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

$lo/lou_{min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, 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 $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu (4.10) = 0.7393216$
 $M_{Rc} (4.17) = 1.6991E+008$

--->

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, 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00

```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi (5A.5, TBDY) = 0.002$
 Final value of ϕ : $\phi^* = \text{shear_factor} * \text{Max}(\phi_c, \phi_s) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_c = 0.01061002$
 $\phi_s (5.4c) = 0.03159521$
 $\phi_{se} ((5.4d), TBDY) = (\phi_{se1} * A_{ext} + \phi_{se2} * A_{int}) / A_{sec} = 0.15755208$
 $\phi_{se1} = 0.15755208$
 $b_{o_1} = 160.00$
 $h_{o_1} = 160.00$
 $b_{i2_1} = 102400.00$
 $\phi_{se2} = \text{Max}(\phi_{se1}, \phi_{se2}) = 0.15755208$
 $b_{o_2} = 92.00$
 $h_{o_2} = 92.00$
 $b_{i2_2} = 33856.00$
 $\phi_{sh, \min} * F_{ywe} = \text{Min}(\phi_{sh, x} * F_{ywe}, \phi_{sh, y} * F_{ywe}) = 6.61776$

$\phi_{sh, x} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$
 $\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$\phi_{sh, y} * F_{ywe} = \phi_{sh1} * F_{ywe1} + \phi_{sh2} * F_{ywe2} = 6.61776$
 $\phi_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$A_{sec} = 40000.00$
 $s_1 = 100.00$
 $s_2 = 150.00$

$f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $\phi_c = 0.00228783$
 $\phi_c = \text{confinement factor} = 1.02878$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

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

$\phi_{o/lou, \min} = \phi_b / \phi_d = 1.00$

$\phi_{su1} = 0.4 * \phi_{su1_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\phi_{su1_nominal} = 0.08$,

For calculation of $\phi_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $f_{sy1} = f_{s1} / 1.2$, from table 5.1, TBDY.

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

with $f_{s1} = (f_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + f_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 694.45$

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

$y_2 = 0.0025$
 $sh_2 = 0.008$


```

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) = 0.93591561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
    c = confinement factor = 1.02878
    1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
    2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
    v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u(4.11) = 0.65248434$

$M_{Ro}(4.18) = 1.2423E+008$

$M_{Ro} < 0.8 * M_{Rc}$

--->

$u = c_u$ (unconfined full section) = $8.6451905E-005$

$\mu_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 8.6451905E-005$

$\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

$w_e(5.4c) = 0.03159521$

$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$

$a_{se1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.61776$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.61776$

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

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

No stirrups, $n_{s_1} = 2.00$

$h_1 = 200.00$

$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirrups, $n_{s_2} = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{\text{ColO}} = 262044.453$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6564195\text{E-}010$

$\nu_u = 1.1598602\text{E-}029$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$

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

$V_{\text{ColO}} = 262044.453$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6564195\text{E-}010$

$\nu_u = 1.1598602\text{E-}029$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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
Av = 100530.965
fy = 555.56
s = 150.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.875
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 = 15.00
Mean Confinement Factor overall section = 1.02878
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_u, min >= 1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 7.1018611E-046
EDGE -B-

Shear Force, $V_b = -7.1018611E-046$
 BOTH EDGES
 Axial Force, $F = -954435.753$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 0.00$
 -Compression: $As_c = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 1476.549$
 -Compression: $As_{l,com} = 1476.549$
 -Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
 with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 8.6451905E-005$
 $M_u = 1.6991E+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$

$f_c = 33.00$
 $\phi_c (5A.5, \text{TBDY}) = 0.002$

Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_{cu} = 0.01061002$

we (5.4c) $= 0.03159521$

$ase ((5.4d), \text{TBDY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$

$ase1 = 0.15755208$

$bo_1 = 160.00$

$ho_1 = 160.00$

$bi2_1 = 102400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.15755208$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi2_2 = 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.61776$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$

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

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h1 = 200.00$

$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$

Ash2 = Astir_2*ns_2 = 100.531
 No stirups, ns_2 = 2.00
 h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
 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 = 0.00167552
 Ash2 = Astir_2*ns_2 = 100.531
 No stirups, ns_2 = 2.00
 h2 = 100.00

Asec = 40000.00
 s1 = 100.00
 s2 = 150.00
 fywe1 = 694.45
 fywe2 = 694.45
 fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783
 c = confinement factor = 1.02878

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  $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$ 
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 0.93591561$ 
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 0.93591561$ 
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.51774055$ 
and confined core properties:
 $b = 160.00$ 
 $d = 146.00$ 
 $d' = 14.00$ 
 $f_{cc} \text{ (5A.2, TBDY)} = 33.94983$ 
 $cc \text{ (5A.5, TBDY)} = 0.00228783$ 
 $c = \text{confinement factor} = 1.02878$ 
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1}/f_c) = 1.33015$ 
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2}/f_c) = 1.33015$ 
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv}/f_c) = 0.73582989$ 
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
 $v < v_{s,c}$  - 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
---->
 $\epsilon_{cu} \text{ (4.10)} = 0.7393216$ 
 $M_{Rc} \text{ (4.17)} = 1.6991E+008$ 
---->
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  $b \cdot d$ 
-  $f_{cc}, cc$  parameters of confined concrete,  $f_{cc}, cc$ , 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 not satisfied
---->
 $v^* < v^*_{c,y1}$  - RHS eq.(4.6) is not satisfied
---->
 $\epsilon^*_{cu} \text{ (4.11)} = 0.65248434$ 
 $M_{Ro} \text{ (4.18)} = 1.2423E+008$ 
 $M_{Ro} < 0.8 \cdot M_{Rc}$ 
---->
 $u = \epsilon_{cu} \text{ (unconfined full section)} = 8.6451905E-005$ 
 $\mu = M_{Rc}$ 

```

Calculation of ratio l_b/l_d

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

Calculation of Mu1-

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

$$\mu = 8.6451905E-005$$

$$Mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$v = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_o) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.01061002$$

$$\mu_o \text{ (5.4c)} = 0.03159521$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$$

$$a_{se1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.61776$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005

Mu = 1.6991E+008

with full section properties:

b = 200.00

d = 166.00

d' = 34.00

v = 0.87115348

N = 954435.753

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01061002

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01061002

we (5.4c) = 0.03159521

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208

ase1 = 0.15755208

bo_1 = 160.00

ho_1 = 160.00

bi2_1 = 102400.00

ase2 = Max(ase1,ase2) = 0.15755208

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 150.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783
c = confinement factor = 1.02878

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,tens,jacket + fs,core*Asl,tens,core)/Asl,tens = 694.45

with Es1 = (Es,jacket*Asl,tens,jacket + Es,core*Asl,tens,core)/Asl,tens = 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*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) = 0.93591561
2 = Aslcom/(b*d)*(fs2/fc) = 0.93591561
v = Aslmid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Aslten/(b*d)*(fs1/fc) = 1.33015
2 = Aslcom/(b*d)*(fs2/fc) = 1.33015
v = Aslmid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*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 not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->

```

u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01061002

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01061002

we (5.4c) = 0.03159521

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208

ase1 = 0.15755208

bo_1 = 160.00

ho_1 = 160.00

bi2_1 = 102400.00

ase2 = Max(ase1,ase2) = 0.15755208

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776

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 = 0.00167552

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776

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 = 0.00167552

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
 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 $fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$
 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
 $\text{Shear_factor} = 1.00$
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$
 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 $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$
 with $Es_v = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 0.93591561$
 $2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015$
 $2 = Asl,com/(b*d)*(fs2/fc) = 1.33015$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->

$v < v_{s,c}$ - 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) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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 $b*d$
- f_{cc}, ϵ_{cc} parameters of confined concrete, f_{cc}, ϵ_{cc} used in lieu of f_c, ϵ_{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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8*M_{Rc}$

--->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$\mu = M_{Rc}$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{ColO} = 262044.453$

$k_{nl} = 1$ (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)

$M/V_d = 2.00$

$\mu_u = 2.9879866E-010$

$V_u = 7.1018611E-046$

$d = 0.8*h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 122116.319$
 $bw = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$
 $V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Col0}$
 $V_{Col0} = 262044.453$
 $knl = 1$ (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)
 $M/Vd = 2.00$
 $M_u = 2.9879866E-010$
 $V_u = 7.1018611E-046$
 $d = 0.8 * h = 160.00$
 $N_u = 954435.753$
 $A_g = 40000.00$
 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:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 555.56$
 $s = 150.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 1.875$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 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: 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, $c = 15.00$
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 ($l_b/d \geq 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -2.6971E+008$
Shear Force, $V_2 = -1653.244$
Shear Force, $V_3 = -5.2953879E-010$
Axial Force, $F = -952465.534$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 1476.549$
-Compression: $As_c = 2293.363$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1476.549$
-Compression: $As_{l,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 1014.734$
-Compression: $As_{l,com,jacket} = 1014.734$
-Middle: $As_{l,mid,jacket} = 508.938$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,core} = 461.8141$
-Compression: $As_{l,com,core} = 461.8141$
-Middle: $As_{l,mid,core} = 307.8761$
Mean Diameter of Tension Reinforcement, $Db_L = 17.33333$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.07886699$
 $u = \gamma + p = 0.07886699$

- Calculation of γ -

$y = (M_y * L_s / 3) / E_{eff} = 0.07534979$ ((4.29), Biskinis Phd))
 $M_y = 9.4939E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 6000.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.5199E+012$
 $factor = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_{c'}^{jacket} * Area_{jacket} + f_{c'}^{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 952465.534$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.0444941E-005$
 with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58625889$
 $A = 0.16519083$
 $B = 0.12004383$
 with $p_t = 0.0095295$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
 $N = 952465.534$
 $b = 200.00$
 $\rho = 0.20481928$
 $y_{comp} = 1.8657650E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
 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: $p = 0.0035172$

with:

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

shear control ratio $V_y E / V_{col} E = 0.43225659$

$d = d_{external} = 166.00$

$s = s_{external} = 150.00$

$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.0095295$

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: $s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00167552$

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

$h_2 = 100.00$

$s_2 = 150.00$

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

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

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

For the normalisation f_s of jacket is used.

$N_{UD} = 952465.534$

$A_g = 40000.00$

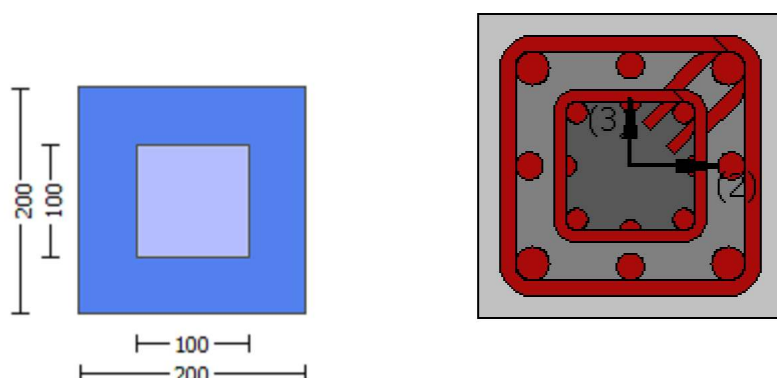
$f_{cE} = (f_{c,jacket} * Area_{jacket} + f_{c,core} * Area_{core}) / section_area = 33.00$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$
 $f_{yE} = (f_{y_ext_Trans_Reinf} \cdot Area_ext_Trans_Reinf + f_{y_int_Trans_Reinf} \cdot Area_int_Trans_Reinf) / Area_Tot_Trans_Rein = 555.56$
 $\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.11355154$
 $b = 200.00$
 $d = 166.00$
 $f_{cE} = 33.00$

 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 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 γ 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, $c = 15.00$
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, $M_a = -2.6971E+008$
Shear Force, $V_a = -1653.244$
EDGE -B-
Bending Moment, $M_b = -448047.023$
Shear Force, $V_b = 1653.244$
BOTH EDGES
Axial Force, $F = -952465.534$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 1476.549$
-Compression: $A_{st,com} = 1476.549$
-Middle: $A_{st,mid} = 816.8141$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.33333$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 165062.473$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 165062.473$
 $V_{CoI} = 235803.533$
 $k_n = 0.70$
displacement_ductility_demand = 9.90562

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)

$$M/Vd = 2.00$$

$$\mu_u = 448047.023$$

$$V_u = 1653.244$$

$$d = 0.8 \cdot h = 160.00$$

$$N_u = 952465.534$$

$$A_g = 40000.00$$

$$\text{From (11.5.4.8), ACI 318-14: } V_s = V_{s1} + V_{s2} = 125663.706$$

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:

$$d = 80.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 150.00$$

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

$$s/d = 1.875$$

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

$$\text{From (11-11), ACI 440: } V_s + V_f \leq 106288.613$$

$$b_w = 200.00$$

displacement ductility demand is calculated as δ_u / y

- Calculation of δ_u / y for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta_r = 0.03731933$

$$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00376749 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 9.4939\text{E}+007$$

$$L_s = M/V \text{ (with } L_s > 0.1 \cdot L \text{ and } L_s < 2 \cdot L) = 300.00$$

$$\text{From table 10.5, ASCE 41_17: } E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 2.5199\text{E}+012$$

$$\text{factor} = 0.70$$

$$A_g = 40000.00$$

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

$$N = 952465.534$$

$$E_c \cdot I_g = E_{c_jacket} \cdot I_{g_jacket} + E_{c_core} \cdot I_{g_core} = 3.5999\text{E}+012$$

Calculation of Yielding Moment M_y

Calculation of δ_u / y and M_y according to Annex 7 -

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

$$y_{\text{ten}} = 4.0444941\text{E}-005$$

$$\text{with } f_y = 555.56$$

$$d = 166.00$$

$$y = 0.58625889$$

$$A = 0.16519083$$

$$B = 0.12004383$$

$$\text{with } p_t = 0.04447435$$

$$p_c = 0.04447435$$

$$p_v = 0.02460283$$

$$N = 952465.534$$

$$b = 200.00$$

$$\rho = 0.20481928$$

$$y_{\text{comp}} = 1.8657650\text{E}-005$$

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

$$E_c = 26999.444$$

$y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
 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. 14

column C1, Floor 1

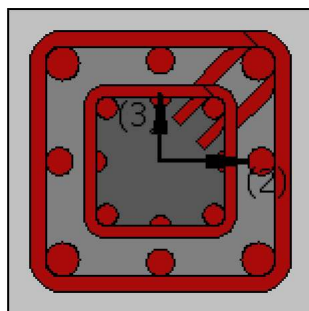
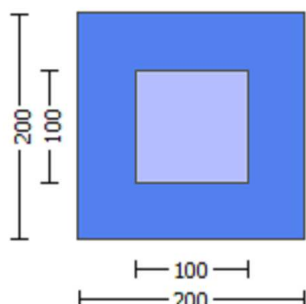
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (ϕ)

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, $c = 15.00$
 Mean Confinement Factor overall section = 1.02878
 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, $V_a = -1.1598602E-029$
 EDGE -B-
 Shear Force, $V_b = 1.1598602E-029$
 BOTH EDGES
 Axial Force, $F = -954435.753$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $A_{slt} = 0.00$
 -Compression: $A_{slc} = 3769.911$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $A_{sl,ten} = 1476.549$
 -Compression: $A_{sl,com} = 1476.549$
 -Middle: $A_{sl,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
 Member Controlled by Flexure ($V_e/V_r < 1$)
 Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
 with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

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

$$\phi_u = 8.6451905E-005$$

$$\mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

$$\phi_{0.5A} (5A.5, TBDY) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{we} (5.4c) = 0.03159521$$

$$\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{ase1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$f_{t1} = 833.34$$

$$f_{y1} = 694.45$$

$$su_1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

$psh_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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.

$y1, sh1, ft1, fy1$, 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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

Calculation of ratio l_b/d

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

Calculation of μ_{2+}

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

$$\mu = 8.6451905E-005$$

$$\mu_u = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu_u = 0.01061002$$

$$\mu_w (5.4c) = 0.03159521$$

$$\mu_{se} ((5.4d), \text{TB DY}) = (\mu_{se1} * A_{ext} + \mu_{se2} * A_{int}) / A_{sec} = 0.15755208$$

$$\mu_{se1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\mu_{se2} = \text{Max}(\mu_{se1}, \mu_{se2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\mu_{psh, \min} * F_{ywe} = \text{Min}(\mu_{psh, x} * F_{ywe}, \mu_{psh, y} * F_{ywe}) = 6.61776$$

$$\mu_{psh, x} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\mu_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\mu_{psh, y} * F_{ywe} = \mu_{psh1} * F_{ywe1} + \mu_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\mu_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_c = 0.00228783$$

$$\mu_c = \text{confinement factor} = 1.02878$$

```

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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

---->

c_u (4.10) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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 $b * d$
- f_c , c_c parameters of confined concrete, f_{cc} , c_c , used in lieu of f_c , c_u

---->

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 not satisfied

---->

$v^* < v^* c, y_1$ - RHS eq.(4.6) is not satisfied

---->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 * M_{Rc}$

---->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$M_u = M_{Rc}$

Calculation of ratio I_b/I_d

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

Calculation of M_{u2} -

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

$u = 8.6451905E-005$

$M_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

c_o (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

w_e (5.4c) = 0.03159521

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$

```

ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

Asec = 40000.00
s1 = 100.00
s2 = 150.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

```

From ((5.A5), TBDY), TBDY: cc = 0.00228783
c = confinement factor = 1.02878

```

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 $Esv = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 0.93591561$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 0.93591561$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten} / (b \cdot d) \cdot (fs1/fc) = 1.33015$
 $2 = Asl_{com} / (b \cdot d) \cdot (fs2/fc) = 1.33015$
 $v = Asl_{mid} / (b \cdot d) \cdot (fsv/fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->
 $v < v_{s,c}$ - 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
 --->
 $cu (4.10) = 0.7393216$
 $MRC (4.17) = 1.6991E+008$
 --->
 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 $b \cdot d$
 - 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 not satisfied

```

--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 262044.453
-----
Calculation of Shear Strength at edge 1, Vr1 = 262044.453
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VColO
VColO = 262044.453
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 = 3.6564195E-010
Vu = 1.1598602E-029
d = 0.8*h = 160.00
Nu = 954435.753
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 = 150.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.875
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 = 262044.453
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VColO
VColO = 262044.453
knl = 1 (zero step-static loading)
-----
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----
= 1 (normal-weight concrete)

```

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

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$\nu_u = 1.1598602E-029$

$d = 0.8 \cdot h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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, $c = 15.00$
Mean Confinement Factor overall section = 1.02878
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, $V_a = 7.1018611E-046$
EDGE -B-
Shear Force, $V_b = -7.1018611E-046$
BOTH EDGES
Axial Force, $F = -954435.753$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 1476.549$
-Compression: $As_{c,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
with
 $M_{pr1} = \max(\mu_{u1+}, \mu_{u1-}) = 1.6991E+008$
 $\mu_{u1+} = 1.6991E+008$, 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
 $\mu_{u1-} = 1.6991E+008$, 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
 $M_{pr2} = \max(\mu_{u2+}, \mu_{u2-}) = 1.6991E+008$
 $\mu_{u2+} = 1.6991E+008$, 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
 $\mu_{u2-} = 1.6991E+008$, 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 μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 8.6451905E-005$
 $\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\alpha_1(5A_s, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \max(\mu_u, \alpha_1) = 0.01061002$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.01061002$

$w_e (5.4c) = 0.03159521$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$
 $a_{se1} = 0.15755208$
 $b_{o_1} = 160.00$
 $h_{o_1} = 160.00$
 $b_{i2_1} = 102400.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$
 $b_{o_2} = 92.00$
 $h_{o_2} = 92.00$
 $b_{i2_2} = 33856.00$
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.61776$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.61776$
 $p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 $\text{No stirups, } n_{s_1} = 2.00$
 $h_1 = 200.00$
 $p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 $\text{No stirups, } n_{s_2} = 2.00$
 $h_2 = 100.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.61776$
 $p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 $\text{No stirups, } n_{s_1} = 2.00$
 $h_1 = 200.00$
 $p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 $\text{No stirups, } n_{s_2} = 2.00$
 $h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 150.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$

$c = \text{confinement factor} = 1.02878$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

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

$su_1 = 0.4 * esu_1_{\text{nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_1_{\text{nominal}} = 0.08$,

For calculation of esu_1_{nominal} and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fs_1 = fs_1 / 1.2$, from table 5.1, TBDY.

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

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

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

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

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

$su_2 = 0.4 * esu_2_{\text{nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_2_{\text{nominal}} = 0.08$,

For calculation of $es_{u2_nominal}$ and y_2 , sh_2 , 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

$lo/lou_{min} = l_b/l_d = 1.00$
 $suv = 0.4 \cdot esuv_nominal \text{ ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esuv_nominal = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $esuv_nominal$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, 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 $Es_v = (Es_{jacket} \cdot Asl_{mid,jacket} + Es_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 200000.00$

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $f_{cc} \text{ (5A.2, TBDY)} = 33.94983$
 $cc \text{ (5A.5, TBDY)} = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/f_c) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/f_c) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/f_c) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu \text{ (4.10)} = 0.7393216$
 $M_{Rc} \text{ (4.17)} = 1.6991E+008$

--->

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, 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00

```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $co(5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01061002$
 $w_e(5.4c) = 0.03159521$
 $ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.61776$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$
 $ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirrups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirrups, $ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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

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

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

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

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

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

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

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/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/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/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) = 0.93591561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
    c = confinement factor = 1.02878
    1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
    2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
    v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u(4.11) = 0.65248434$

$M_{Ro}(4.18) = 1.2423E+008$

$M_{Ro} < 0.8 * M_{Rc}$

--->

$u = c_u$ (unconfined full section) = $8.6451905E-005$

$\mu_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of μ_{u2} -

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

$u = 8.6451905E-005$

$\mu_u = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01061002$

$w_e(5.4c) = 0.03159521$

$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.15755208$

$a_{se1} = 0.15755208$

$b_{o_1} = 160.00$

$h_{o_1} = 160.00$

$b_{i2_1} = 102400.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.15755208$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.61776$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.61776$

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

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

No stirups, $n_{s_1} = 2.00$

$h_1 = 200.00$

$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$

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

No stirups, $n_{s_2} = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*cy2 - LHS eq.(4.6) is not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{Col0} = 262044.453$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 262044.453$

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

$V_{Col0} = 262044.453$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.9879866E-010$

$\nu_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.875
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, $c = 15.00$
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, $M = 7.1301600E-007$
Shear Force, $V_2 = 1653.244$
Shear Force, $V_3 = 5.2953879E-010$
Axial Force, $F = -952465.534$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3769.911$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{l,ten} = 1476.549$
-Compression: $As_{l,com} = 1476.549$
-Middle: $As_{l,mid} = 816.8141$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl_{ten,jacket} = 1014.734$
 -Compression: $Asl_{com,jacket} = 1014.734$
 -Middle: $Asl_{mid,jacket} = 508.938$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $Asl_{ten,core} = 461.8141$
 -Compression: $Asl_{com,core} = 461.8141$
 -Middle: $Asl_{mid,core} = 307.8761$
 Mean Diameter of Tension Reinforcement, $DbL = 17.33333$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.02235465$
 $u = y + p = 0.02235465$

- Calculation of y -

$y = (My * L_s / 3) / E_{eff} = 0.01883745$ ((4.29), Biskinis Phd))
 $My = 9.4939E+007$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 2.5199E+012$
 $factor = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 952465.534$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.0444941E-005$
 with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58625889$
 $A = 0.16519083$
 $B = 0.12004383$
 with $pt = 0.0095295$
 $pc = 0.04447435$
 $pv = 0.02460283$
 $N = 952465.534$
 $b = 200.00$
 $" = 0.20481928$
 $y_{comp} = 1.8657650E-005$
 with $fc = 33.00$
 $E_c = 26999.444$
 $y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
 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: $p = 0.0035172$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$
 shear control ratio $V_y E / V_{col} I_{OE} = 0.43225659$

```

d = d_external = 166.00
s = s_external = 150.00
t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.0095295
jacket: s1 = Av1*h1/(s1*Ag) = 0.00785398
        Av1 = 157.0796, is the total area of all stirrups parallel to loading (shear) direction
        h1 = 200.00
        s1 = 100.00
core: s2 = Av2*h2/(s2*Ag) = 0.00167552
        Av2 = 100.531, is the total area of all stirrups parallel to loading (shear) direction
        h2 = 100.00
        s2 = 150.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
All these variables have already been given in Shear control ratio calculation.
For the normalisation fs of jacket is used.
NUD = 952465.534
Ag = 40000.00
fcE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fyIE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein =
555.56
fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein =
555.56
pl = Area_Tot_Long_Rein/(b*d) = 0.11355154
b = 200.00
d = 166.00
fcE = 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

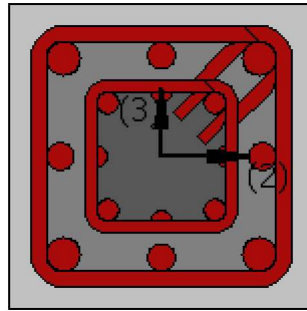
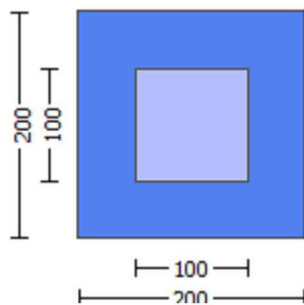
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)



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

At local axis: 3

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

New material of 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 γ 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, $c = 15.00$

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, $M_a = -4.3546420E-006$

Shear Force, $V_a = -5.2953879E-010$

EDGE -B-
 Bending Moment, Mb = 7.1301600E-007
 Shear Force, Vb = 5.2953879E-010
 BOTH EDGES
 Axial Force, F = -952465.534
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Aslt = 0.00
 -Compression: Aslc = 3769.911
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl,ten = 1476.549
 -Compression: Asl,com = 1476.549
 -Middle: Asl,mid = 816.8141
 Mean Diameter of Tension Reinforcement, DbL,ten = 17.33333

 New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 235803.533
 Vn ((10.3), ASCE 41-17) = knl*VCol0 = 235803.533
 VCol = 235803.533
 knl = 1.00
 displacement_ductility_demand = 3.8524739E-014

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

 = 1 (normal-weight concrete)
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc'^0.5 <= 8.3
 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
 Mu = 7.1301600E-007
 Vu = 5.2953879E-010
 d = 0.8*h = 160.00
 Nu = 952465.534
 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 = 150.00
 Vs2 is multiplied by Col2 = 0.00
 s/d = 1.875
 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 / y

 - Calculation of / y for END B -
 for rotation axis 2 and integ. section (b)

 From analysis, chord rotation = 7.2669656E-016
 y = (My*Ls/3)/Eleff = 0.01883745 ((4.29),Biskinis Phd))
 My = 9.4939E+007
 Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
 From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.5199E+012

factor = 0.70
Ag = 40000.00
Mean concrete strength: $fc' = (fc'_{jacket} \cdot Area_{jacket} + fc'_{core} \cdot Area_{core}) / Area_{section} = 33.00$
N = 952465.534
 $Ec \cdot Ig = Ec_{jacket} \cdot Ig_{jacket} + Ec_{core} \cdot Ig_{core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 4.0444941E-005$
with $f_y = 555.56$
 $d = 166.00$
 $y = 0.58625889$
 $A = 0.16519083$
 $B = 0.12004383$
with $p_t = 0.04447435$
 $p_c = 0.04447435$
 $p_v = 0.02460283$
N = 952465.534
 $b = 200.00$
 $" = 0.20481928$
 $y_{comp} = 1.8657650E-005$
with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
with $Es = 200000.00$

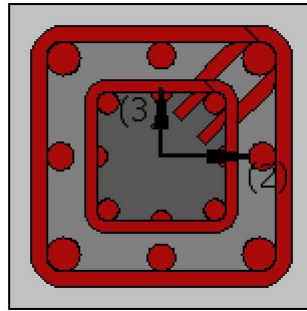
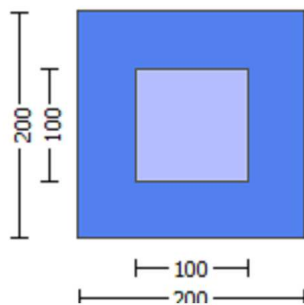
Calculation of ratio I_b/I_d

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: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)
Analysis: Uniform +X
Check: Chord rotation capacity (ϕ_r)
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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878

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, $V_a = -1.1598602E-029$

EDGE -B-

Shear Force, $V_b = 1.1598602E-029$

BOTH EDGES

Axial Force, $F = -954435.753$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3769.911$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 1476.549$

-Compression: $As_{c,com} = 1476.549$

-Middle: $As_{mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$
with

$M_{pr1} = \text{Max}(\mu_{1+}, \mu_{1-}) = 1.6991\text{E}+008$

$\mu_{1+} = 1.6991\text{E}+008$, 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

$\mu_{1-} = 1.6991\text{E}+008$, 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

$M_{pr2} = \text{Max}(\mu_{2+}, \mu_{2-}) = 1.6991\text{E}+008$

$\mu_{2+} = 1.6991\text{E}+008$, 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

$\mu_{2-} = 1.6991\text{E}+008$, 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 μ_{1+}

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

$\phi_u = 8.6451905\text{E}-005$

$M_u = 1.6991\text{E}+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_{co}) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01061002$

we (5.4c) $= 0.03159521$

$ase ((5.4d), \text{TBDY}) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.15755208$

$ase1 = 0.15755208$

$bo_1 = 160.00$

$ho_1 = 160.00$

$bi2_1 = 102400.00$

$ase2 = \text{Max}(ase1, ase2) = 0.15755208$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi2_2 = 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.61776$

$psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.61776$

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

$Ash1 = Astir_1 * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h1 = 200.00$

$ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00167552$

$Ash2 = Astir_2 * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.61776 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00167552 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 150.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{TB DY}), \text{TB DY: } cc = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

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

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 $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, 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

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

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

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 $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, 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

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

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

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

```

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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*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 not satisfied
---->
v* < v*cy1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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

```

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

$$\phi_u = 8.6451905E-005$$

$$\mu = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

$$\phi_{0.5A} (5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01061002$$

$$\phi_{we} (5.4c) = 0.03159521$$

$$\phi_{ase} ((5.4d), \text{TBDY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$$

$$\phi_{ase1} = 0.15755208$$

$$b_{o_1} = 160.00$$

$$h_{o_1} = 160.00$$

$$b_{i2_1} = 102400.00$$

$$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$$

$$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$$

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

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

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\phi_{ps2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

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

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00228783$$

$$c = \text{confinement factor} = 1.02878$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
--->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
--->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
--->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
--->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----
with full section properties:
b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

$psh_x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$Asec = 40000.00$
 $s1 = 100.00$
 $s2 = 150.00$
 $fywe1 = 694.45$
 $fywe2 = 694.45$
 $fce = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$

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

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

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

$su1 = 0.4 \cdot esu1_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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
 $\text{Shear_factor} = 1.00$

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

$su2 = 0.4 \cdot esu2_nominal \text{ ((5.5), TBDY)} = 0.032$

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

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/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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```


Calculation of ratio l_b/d

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

Calculation of μ_u

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

$$\mu_u = 8.6451905E-005$$

$$\mu_u = 1.6991E+008$$

with full section properties:

$$b = 200.00$$

$$d = 166.00$$

$$d' = 34.00$$

$$\nu = 0.87115348$$

$$N = 954435.753$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu_u: \mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01061002$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TB DY: } \mu_u = 0.01061002$$

$$\omega (5.4c) = 0.03159521$$

$$\omega (5.4d), \text{TB DY} = (\omega_1 * A_{ext} + \omega_2 * A_{int}) / A_{sec} = 0.15755208$$

$$\omega_1 = 0.15755208$$

$$b_{o1} = 160.00$$

$$h_{o1} = 160.00$$

$$b_{i1} = 102400.00$$

$$\omega_2 = \text{Max}(\omega_1, \omega_2) = 0.15755208$$

$$b_{o2} = 92.00$$

$$h_{o2} = 92.00$$

$$b_{i2} = 33856.00$$

$$\mu_{sh, \min} * F_{ywe} = \text{Min}(\mu_{sh, x} * F_{ywe}, \mu_{sh, y} * F_{ywe}) = 6.61776$$

$$\mu_{sh, x} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 6.61776$$

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

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 200.00$$

$$\mu_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 100.00$$

$$\mu_{sh, y} * F_{ywe} = \mu_{sh1} * F_{ywe1} + \mu_{sh2} * F_{ywe2} = 6.61776$$

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

$$A_{sh1} = A_{stir1} * n_{s1} = 157.0796$$

$$\text{No stirrups, } n_{s1} = 2.00$$

$$h_1 = 200.00$$

$$\mu_{sh2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$$

$$A_{sh2} = A_{stir2} * n_{s2} = 100.531$$

$$\text{No stirrups, } n_{s2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 150.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TB DY), TB DY: } \mu_c = 0.00228783$$

$$\mu_c = \text{confinement factor} = 1.02878$$

```

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) = 0.93591561
2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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

---->

ϵ_{cu} (4.10) = 0.7393216

M_{Rc} (4.17) = 1.6991E+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*d_o , instead of $b*d$
- parameters of confined concrete, f_{cc} , ϵ_{cc} , used in lieu of f_c , ϵ_{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 not satisfied

---->

$v^* < v^*c, y_1$ - RHS eq.(4.6) is not satisfied

---->

ϵ^*_{cu} (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8*M_{Rc}$

---->

$u = \epsilon_{cu}$ (unconfined full section) = 8.6451905E-005

$\mu_u = M_{Rc}$

Calculation of ratio l_b/l_d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

$V_{r1} = V_{Co1}$ ((10.3), ASCE 41-17) = $k_n l^* V_{Co10}$

$V_{Co10} = 262044.453$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 3.6564195E-010$

$V_u = 1.1598602E-029$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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 = 262044.453

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

VCol0 = 262044.453

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 = 3.6564195E-010

Vu = 1.1598602E-029

d = 0.8*h = 160.00

Nu = 954435.753

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 = 150.00

Vs2 is multiplied by Col2 = 0.00

s/d = 1.875

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, $\gamma = 1.00$

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, $c = 15.00$

Mean Confinement Factor overall section = 1.02878

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, $V_a = 7.1018611E-046$

EDGE -B-

Shear Force, $V_b = -7.1018611E-046$

BOTH EDGES

Axial Force, $F = -954435.753$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3769.911$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 1476.549$

-Compression: $A_{st,com} = 1476.549$

-Middle: $A_{st,mid} = 816.8141$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.43225659$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 113270.442$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.6991E+008$

$M_{u1+} = 1.6991E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction

which is defined for the static loading combination

$Mu1- = 1.6991E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$Mpr2 = \text{Max}(Mu2+ , Mu2-) = 1.6991E+008$

$Mu2+ = 1.6991E+008$, 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

$Mu2- = 1.6991E+008$, 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 ϕ_u according to 4.1, Biskinis/Fardis 2013:

$u = 8.6451905E-005$

$Mu = 1.6991E+008$

with full section properties:

$b = 200.00$

$d = 166.00$

$d' = 34.00$

$v = 0.87115348$

$N = 954435.753$

$f_c = 33.00$

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

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01061002$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TB DY: $\phi_u = 0.01061002$

$\phi_{ue} (5.4c) = 0.03159521$

$\phi_{ase} ((5.4d), \text{TB DY}) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$

$\phi_{ase1} = 0.15755208$

$\phi_{bo_1} = 160.00$

$\phi_{ho_1} = 160.00$

$\phi_{bi2_1} = 102400.00$

$\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$

$\phi_{bo_2} = 92.00$

$\phi_{ho_2} = 92.00$

$\phi_{bi2_2} = 33856.00$

$\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$

$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$

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

$\phi_{Ash1} = \phi_{Astir_1} * n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h1 = 200.00$

$\phi_{ps2} (\text{internal}) = (\phi_{Ash2} * h2 / s2) / A_{sec} = 0.00167552$

$\phi_{Ash2} = \phi_{Astir_2} * n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h2 = 100.00$

$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$

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

$\phi_{Ash1} = \phi_{Astir_1} * n_{s_1} = 157.0796$

No stirrups, $n_{s_1} = 2.00$

$h1 = 200.00$

$\phi_{ps2} (\text{internal}) = (\phi_{Ash2} * h2 / s2) / A_{sec} = 0.00167552$

$\phi_{Ash2} = \phi_{Astir_2} * n_{s_2} = 100.531$

No stirrups, $n_{s_2} = 2.00$

$h2 = 100.00$

$A_{sec} = 40000.00$

$s1 = 100.00$

$s2 = 150.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5A.5), TBDY), TBDY: $cc = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$
 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 $Es_v = (Es_jacket * Asl, \text{mid}, \text{jacket} + Es_mid * Asl, \text{mid}, \text{core}) / Asl, \text{mid} = 200000.00$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 0.93591561$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 0.93591561$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.51774055$
 and confined core properties:
 $b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl, \text{ten} / (b * d) * (fs1 / fc) = 1.33015$
 $2 = Asl, \text{com} / (b * d) * (fs2 / fc) = 1.33015$
 $v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.73582989$
 Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)
 --->

$v < v_{s,c}$ - 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) = 0.7393216
 M_{Rc} (4.17) = 1.6991E+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 $b*d$
 - f_{cc}, c_c parameters of confined concrete, f_{cc}, c_c used in lieu of f_c, e_c
 --->
 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 not satisfied
 --->
 $v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied
 --->
 $*c_u$ (4.11) = 0.65248434
 M_{Ro} (4.18) = 1.2423E+008
 $M_{Ro} < 0.8*M_{Rc}$
 --->
 $u = c_u$ (unconfined full section) = 8.6451905E-005
 $M_u = M_{Rc}$

 Calculation of ratio I_b/I_d

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

Calculation of M_{u1} -

 Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 8.6451905E-005$
 $M_u = 1.6991E+008$

with full section properties:

$b = 200.00$
 $d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 c_o (5A.5, TBDY) = 0.002
 Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.01061002$

$w_e(5.4c) = 0.03159521$
 $ase((5.4d), TBDY) = (ase1 \cdot A_{ext} + ase2 \cdot A_{int}) / A_{sec} = 0.15755208$
 $ase1 = 0.15755208$
 $bo_1 = 160.00$
 $ho_1 = 160.00$
 $bi2_1 = 102400.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.15755208$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min \cdot Fywe = \text{Min}(psh, x \cdot Fywe, psh, y \cdot Fywe) = 6.61776$

$psh, x \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1(\text{external}) = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$psh, y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.61776$
 $ps1(\text{external}) = (Ash1 \cdot h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 \cdot ns_1 = 157.0796$
 $\text{No stirups, } ns_1 = 2.00$
 $h1 = 200.00$
 $ps2(\text{internal}) = (Ash2 \cdot h2 / s2) / A_{sec} = 0.00167552$
 $Ash2 = Astir_2 \cdot ns_2 = 100.531$
 $\text{No stirups, } ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$

$s1 = 100.00$

$s2 = 150.00$

$fywe1 = 694.45$

$fywe2 = 694.45$

$fce = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00228783$

$c = \text{confinement factor} = 1.02878$

$y1 = 0.0025$

$sh1 = 0.008$

$ft1 = 833.34$

$fy1 = 694.45$

$su1 = 0.032$

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

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

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

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

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

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

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

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

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

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

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

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

For calculation of $es_{u2_nominal}$ and y_2 , sh_2, ft_2, fy_2 , it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

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

with $fs_2 = (fs_{jacket} \cdot Asl_{com,jacket} + fs_{core} \cdot Asl_{com,core}) / Asl_{com} = 694.45$

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

$lo/lou_{min} = lb/ld = 1.00$
 $suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$, considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

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

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

with $fs_v = (fs_{jacket} \cdot Asl_{mid,jacket} + fs_{mid} \cdot Asl_{mid,core}) / Asl_{mid} = 694.45$

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

$1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 0.93591561$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 0.93591561$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.51774055$

and confined core properties:

$b = 160.00$
 $d = 146.00$
 $d' = 14.00$
 $fcc (5A.2, TBDY) = 33.94983$
 $cc (5A.5, TBDY) = 0.00228783$
 $c = \text{confinement factor} = 1.02878$
 $1 = Asl_{ten}/(b \cdot d) \cdot (fs_1/fc) = 1.33015$
 $2 = Asl_{com}/(b \cdot d) \cdot (fs_2/fc) = 1.33015$
 $v = Asl_{mid}/(b \cdot d) \cdot (fs_v/fc) = 0.73582989$

Case/Assumption: Unconfined full section - Steel rupture
 ' does not satisfy Eq. (4.3)

--->

$v < v_{s,c}$ - 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

--->

$cu (4.10) = 0.7393216$
 $MRC (4.17) = 1.6991E+008$

--->

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, 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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc

```

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 = 8.6451905E-005
Mu = 1.6991E+008

with full section properties:

```

b = 200.00
d = 166.00
d' = 34.00
v = 0.87115348
N = 954435.753
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01061002
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01061002
we (5.4c) = 0.03159521
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.15755208
ase1 = 0.15755208
bo_1 = 160.00
ho_1 = 160.00
bi2_1 = 102400.00
ase2 = Max(ase1,ase2) = 0.15755208
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.61776

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

```

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.61776
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 = 0.00167552
Ash2 = Astir_2*ns_2 = 100.531

```

No stirrups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 150.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00228783

c = confinement factor = 1.02878

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) = 0.93591561

2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561

v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055

and confined core properties:

b = 160.00

d = 146.00

d' = 14.00

```

fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
c = confinement factor = 1.02878
1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied
---->
v* < v*c,y1 - RHS eq.(4.6) is not satisfied
---->
*cu (4.11) = 0.65248434
MRo (4.18) = 1.2423E+008
MRo < 0.8*MRc
---->
u = cu (unconfined full section) = 8.6451905E-005
Mu = MRc
-----

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 = 8.6451905E-005
Mu = 1.6991E+008
-----

with full section properties:
b = 200.00

```

$d = 166.00$
 $d' = 34.00$
 $v = 0.87115348$
 $N = 954435.753$
 $f_c = 33.00$
 $\phi_{co} (5A.5, TBDY) = 0.002$
 Final value of ϕ_{cu} : $\phi_{cu}^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01061002$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $\phi_{cu} = 0.01061002$
 $\phi_{we} (5.4c) = 0.03159521$
 $\phi_{ase} ((5.4d), TBDY) = (\phi_{ase1} * A_{ext} + \phi_{ase2} * A_{int}) / A_{sec} = 0.15755208$
 $\phi_{ase1} = 0.15755208$
 $b_{o_1} = 160.00$
 $h_{o_1} = 160.00$
 $b_{i2_1} = 102400.00$
 $\phi_{ase2} = \text{Max}(\phi_{ase1}, \phi_{ase2}) = 0.15755208$
 $b_{o_2} = 92.00$
 $h_{o_2} = 92.00$
 $b_{i2_2} = 33856.00$
 $\phi_{psh, \min} * F_{ywe} = \text{Min}(\phi_{psh, x} * F_{ywe}, \phi_{psh, y} * F_{ywe}) = 6.61776$

$\phi_{psh, x} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$
 $\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$\phi_{psh, y} * F_{ywe} = \phi_{psh1} * F_{ywe1} + \phi_{ps2} * F_{ywe2} = 6.61776$
 $\phi_{ps1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $\phi_{ps2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00167552$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$A_{sec} = 40000.00$
 $s_1 = 100.00$
 $s_2 = 150.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $\phi_{cc} = 0.00228783$
 $\phi_c = \text{confinement factor} = 1.02878$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

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

$\phi_{lo/lou, \min} = \phi_b / \phi_d = 1.00$

$\phi_{su1} = 0.4 * \phi_{su1_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $\phi_{su1_nominal} = 0.08$,

For calculation of $\phi_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $f_{sy1} = f_{s1} / 1.2$, from table 5.1, TBDY.

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

with $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 694.45$

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

$y_2 = 0.0025$
 $sh_2 = 0.008$

```

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) = 0.93591561
    2 = Asl,com/(b*d)*(fs2/fc) = 0.93591561
    v = Asl,mid/(b*d)*(fsv/fc) = 0.51774055
and confined core properties:
b = 160.00
d = 146.00
d' = 14.00
fcc (5A.2, TBDY) = 33.94983
cc (5A.5, TBDY) = 0.00228783
    c = confinement factor = 1.02878
    1 = Asl,ten/(b*d)*(fs1/fc) = 1.33015
    2 = Asl,com/(b*d)*(fs2/fc) = 1.33015
    v = Asl,mid/(b*d)*(fsv/fc) = 0.73582989
Case/Assumption: Unconfined full section - Steel rupture
' does not satisfy Eq. (4.3)
---->
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) = 0.7393216
MRc (4.17) = 1.6991E+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 not satisfied

--->

$v^* < v^*_{c,y1}$ - RHS eq.(4.6) is not satisfied

--->

$*c_u$ (4.11) = 0.65248434

M_{Ro} (4.18) = 1.2423E+008

$M_{Ro} < 0.8 * M_{Rc}$

--->

$u = c_u$ (unconfined full section) = 8.6451905E-005

$\mu_u = M_{Rc}$

Calculation of ratio l_b/d

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

Calculation of Shear Strength $V_r = \min(V_{r1}, V_{r2}) = 262044.453$

Calculation of Shear Strength at edge 1, $V_{r1} = 262044.453$

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

$V_{ColO} = 262044.453$

$k_{nl} = 1$ (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)

$M/V_d = 2.00$

$\mu_u = 2.9879866E-010$

$V_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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, $V_{r2} = 262044.453$

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

$V_{Col0} = 262044.453$

$knl = 1$ (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)

$M/Vd = 2.00$

$M_u = 2.9879866E-010$

$V_u = 7.1018611E-046$

$d = 0.8 * h = 160.00$

$N_u = 954435.753$

$A_g = 40000.00$

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:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 150.00$

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

$s/d = 1.875$

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

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: 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, $f_c = f_{cm} = 33.00$

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 = 15.00
 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 ($l_b/d \geq 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, M = -448047.023
 Shear Force, V2 = 1653.244
 Shear Force, V3 = 5.2953879E-010
 Axial Force, F = -952465.534
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: Asl_t = 0.00
 -Compression: Asl_c = 3769.911
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten} = 1476.549
 -Compression: Asl_{com} = 1476.549
 -Middle: Asl_{mid} = 816.8141
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten,jacket} = 1014.734
 -Compression: Asl_{com,jacket} = 1014.734
 -Middle: Asl_{mid,jacket} = 508.938
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: Asl_{ten,core} = 461.8141
 -Compression: Asl_{com,core} = 461.8141
 -Middle: Asl_{mid,core} = 307.8761
 Mean Diameter of Tension Reinforcement, DbL = 17.33333

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.00728469$
 $u = y + p = 0.00728469$

- Calculation of y -

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00376749$ ((4.29), Biskinis Phd))
 $M_y = 9.4939E+007$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 2.5199E+012$
 $factor = 0.70$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$
 $N = 952465.534$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \min(y_{ten}, y_{com})$
 $y_{ten} = 4.0444941E-005$
 with $f_y = 555.56$
 $d = 166.00$

$y = 0.58625889$
 $A = 0.16519083$
 $B = 0.12004383$
 with $pt = 0.0095295$
 $pc = 0.04447435$
 $pv = 0.02460283$
 $N = 952465.534$
 $b = 200.00$
 $" = 0.20481928$
 $y_{comp} = 1.8657650E-005$
 with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.71034051$
 $A = 0.04835124$
 $B = 0.06840454$
 with $Es = 200000.00$

Calculation of ratio lb/d

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

- Calculation of p -

From table 10-8: $p = 0.0035172$

with:

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

shear control ratio $VyE/VColOE = 0.43225659$

$d = d_{external} = 166.00$

$s = s_{external} = 150.00$

$t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.0095295$

jacket: $s1 = Av1*h1/(s1*Ag) = 0.00785398$

$Av1 = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h1 = 200.00$

$s1 = 100.00$

core: $s2 = Av2*h2/(s2*Ag) = 0.00167552$

$Av2 = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h2 = 100.00$

$s2 = 150.00$

The term $2*tf/bw*(ffe/fs)$ is implemented to account for FRP contribution

where $f = 2*tf/bw$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

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

For the normalisation fs of jacket is used.

$NUD = 952465.534$

$Ag = 40000.00$

$fcE = (fc_{jacket}*Area_{jacket} + fc_{core}*Area_{core})/section_area = 33.00$

$fyIE = (fy_{ext_Long_Reinf}*Area_{ext_Long_Reinf} + fy_{int_Long_Reinf}*Area_{int_Long_Reinf})/Area_Tot_Long_Rein = 555.56$

$fytE = (fy_{ext_Trans_Reinf}*Area_{ext_Trans_Reinf} + fy_{int_Trans_Reinf}*Area_{int_Trans_Reinf})/Area_Tot_Trans_Rein = 555.56$

$pl = Area_Tot_Long_Rein/(b*d) = 0.11355154$

$b = 200.00$

$d = 166.00$

$fcE = 33.00$

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

At local axis: 3

Integration Section: (b)