

Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

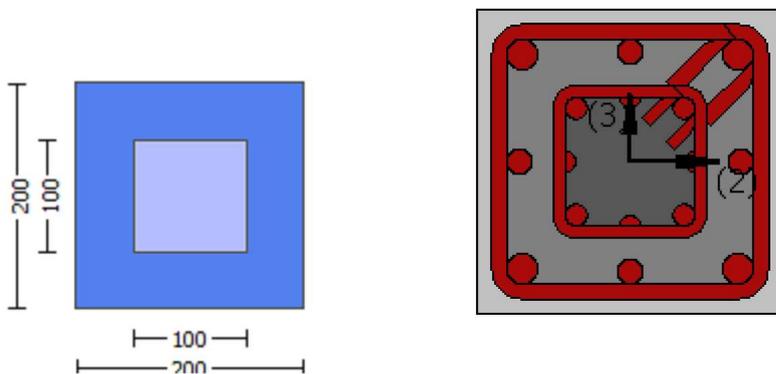
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (2)



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

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

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

Consequently:

Jacket

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

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

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Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
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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 = 10.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou,min} = l_b/l_d >= 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment, Ma = -1.1120E+008
Shear Force, Va = -31530.033
EDGE -B-
Bending Moment, Mb = -6.2875E+006
Shear Force, Vb = 31530.033
BOTH EDGES
Axial Force, F = -218376.72
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension: Aslt = 2001.195
  -Compression: Aslc = 1291.195
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension: Asl,ten = 983.3185
  -Compression: Asl,com = 983.3185
  -Middle: Asl,mid = 1325.752
Mean Diameter of Tension Reinforcement, DbL,ten = 17.50
-----

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 141974.841
Vn ((10.3), ASCE 41-17) = knl*VCol = 141974.841
VCol = 141974.841
knl = 1.00
displacement_ductility_demand = 0.38472951
-----
NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where Vf is the contribution of FRPs (11.3), ACI 440).
-----
= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

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

 displacement ductility demand is calculated as δ_u / y

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

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

 Calculation of Yielding Moment M_y

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

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

A = 0.08128164
B = 0.05564476
with 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

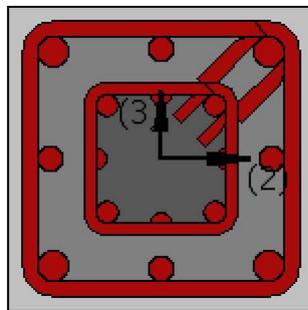
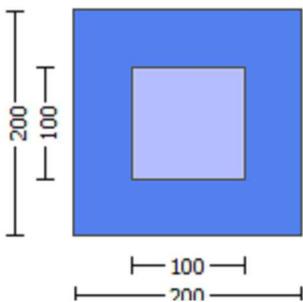
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (2)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

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

Jacket

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

Existing Column

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

#####

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

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

EDGE -B-

Shear Force, $V_b = 8.1187678E-030$

BOTH EDGES

Axial Force, $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 983.3185$

-Compression: $A_{sc,com} = 983.3185$

-Middle: $A_{st,mid} = 1325.752$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.4563967$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.3727E+008$

$M_{u1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.3727E+008$

$M_{u2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

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

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

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

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

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

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

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

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

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

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

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

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

with $fs1 = (fs_jacket \cdot Asl,ten,jacket + fs_core \cdot Asl,ten,core) / Asl,ten = 694.45$

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 $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, 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 $Es_v = (Es_jacket \cdot Asl,mid,jacket + Es_mid \cdot Asl,mid,core) / Asl,mid = 200000.00$

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

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

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

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

$c =$ confinement factor = 1.06329

$1 = Asl,ten / (b \cdot d) \cdot (fs1 / fc) = 0.77530517$

$2 = Asl,com / (b \cdot d) \cdot (fs2 / fc) = 0.77530517$

$v = Asl,mid / (b \cdot d) \cdot (fsv / fc) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs,y2$ - LHS eq.(4.5) is not satisfied

--->

$v < vs,c$ - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

$v < s,y1$ - LHS eq.(4.7) is not satisfied

--->

$v < vc,y1$ - RHS eq.(4.6) is satisfied

--->
 cu (4.10) = 0.45915168
 MRc (4.17) = 1.5179E+008
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: bo, do, d'o
 - N, 1, 2, v normalised to bo*do, instead of b*d
 - - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

--->
 Subcase: Rupture of tension steel

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

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

--->
 Subcase rejected

--->
 New Subcase: Failure of compression zone

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

--->
 *cu (4.12) = 0.51649622
 MRo (4.16) = 1.3727E+008

--->
 u = cu (4.2) = 3.2469244E-005
 Mu = MRo

 Calculation of ratio lb/d

 Adequate Lap Length: lb/d >= 1

 Calculation of Mu1-

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

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

 with full section properties:

b = 200.00
 d = 172.00
 d' = 28.00
 v = 0.19326733
 N = 219397.073
 fc = 33.00
 co (5A.5, TBDY) = 0.002
 Final value of cu: $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01053874$
 w_e (5.4c) = 0.03096488
 ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
 $ase1 = 0.16608997$
 $bo_1 = 170.00$
 $ho_1 = 170.00$
 $bi2_1 = 115600.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 6.15233$

 $psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$

ps1 (external) = $(Ash1 \cdot h1 / s1) / Asec = 0.00785398$
Ash1 = Astir_1 * ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = $(Ash2 \cdot h2 / s2) / Asec = 0.00100531$
Ash2 = Astir_2 * ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

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

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

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

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

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

lo/lou,min = lb/l_d = 1.00

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

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

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

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$, 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/lb,min = 1.00

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

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

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

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/l_d)^{2/3})$, 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

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

$$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$$

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

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

For calculation of $e_{suv_nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered

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

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

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.60153764$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.60153764$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 35.08866$$

$$c_c (5A.5, TBDY) = 0.00263293$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.77530517$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.77530517$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->

$v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied

---->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->

$$c_u (4.10) = 0.45915168$$

$$MR_c (4.17) = 1.5179E+008$$

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o

- $N, 1, 2, v$ normalised to $b_o * d_o$, instead of $b * d$

- f_{cc}, c_c parameters of confined concrete, f_{cc}, c_c , 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 satisfied

---->

$$*c_u (4.12) = 0.51649622$$

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

---->

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

$$\mu_u = MR_o$$

Calculation of ratio l_b/l_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:

$$\mu = 3.2469244E-005$$

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

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

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

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

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

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

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

$$\mu_{ase1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

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

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

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

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

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

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

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

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 35.08866$$

$$cc (5A.5, TBDY) = 0.00263293$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

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

$v < s_1 y_1$ - LHS eq.(4.7) is not satisfied

$v < v_c y_1$ - RHS eq.(4.6) is satisfied

c_u (4.10) = 0.45915168

M_{Rc} (4.17) = 1.5179E+008

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o , d_o , d'_o
- N , 1 , 2 , v normalised to $b_o d_o$, instead of $b d$
- parameters of confined concrete, f_{cc} , c_c , used in lieu of f_c , c_u

Subcase: Rupture of tension steel

$v^* < v^* s_1 y_2$ - 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

$v^* < v^* c_1 y_2$ - LHS eq.(4.6) is satisfied

c_u (4.12) = 0.51649622

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

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

$\mu = M_{Ro}$

Calculation of ratio l_b/d

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

Calculation of μ_2 -

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

$u = 3.2469244E-005$

$\mu = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

c_o (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$

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

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

w_e (5.4c) = 0.03096488

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

$a_{se1} = 0.16608997$

$b_{o1} = 170.00$

$h_{o1} = 170.00$

$b_{i21} = 115600.00$

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

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

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

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

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

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

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

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

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

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

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

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

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

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

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

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

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

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

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

```

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

--->

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

$$\mu = M_{Ro}$$

Calculation of ratio l_b/d

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

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

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

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

$$V_{Col0} = 200506.935$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 4.0616465E-011$$

$$V_u = 8.1187678E-030$$

$$d = 0.8 * h = 160.00$$

$$N_u = 219397.073$$

$$A_g = 40000.00$$

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

where:

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

$$d = 160.00$$

$$A_v = 157079.633$$

$$f_y = 555.56$$

$$s = 100.00$$

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

$$s/d = 0.625$$

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

$$d = 80.00$$

$$A_v = 100530.965$$

$$f_y = 555.56$$

$$s = 250.00$$

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

$$s/d = 3.125$$

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

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

$$b_w = 200.00$$

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

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

$$V_{Col0} = 200506.935$$

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

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

= 1 (normal-weight concrete)

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

$$M/Vd = 2.00$$

$$\mu_u = 4.0616465E-011$$

$$V_u = 8.1187678E-030$$

$d = 0.8 \cdot h = 160.00$
 $Nu = 219397.073$
 $Ag = 40000.00$
 From (11.5.4.8), ACI 318-14: $Vs = Vs1 + Vs2 = 139627.457$
 where:
 $Vs1 = 139627.457$ is calculated for jacket, with:
 $d = 160.00$
 $Av = 157079.633$
 $fy = 555.56$
 $s = 100.00$
 $Vs1$ is multiplied by $Col1 = 1.00$
 $s/d = 0.625$
 $Vs2 = 0.00$ is calculated for core, with:
 $d = 80.00$
 $Av = 100530.965$
 $fy = 555.56$
 $s = 250.00$
 $Vs2$ is multiplied by $Col2 = 0.00$
 $s/d = 3.125$
 $Vf ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $Vs + Vf \leq 122116.319$
 $bw = 200.00$

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

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

Constant Properties

 Knowledge Factor, $\gamma = 1.00$
 Mean strength values are used for both shear and moment calculations.
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $fc = fcm = 33.00$
 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, $fs = 1.25 \cdot fsm = 694.45$
 Existing Column
 New material: Steel Strength, $fs = 1.25 \cdot fsm = 694.45$
 #####

External Height, $H = 200.00$
 External Width, $W = 200.00$
 Internal Height, $H = 100.00$
 Internal Width, $W = 100.00$
 Cover Thickness, $c = 10.00$
 Mean Confinement Factor overall section = 1.06329
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars

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

Stepwise Properties

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

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

Calculation of M_{u1+}

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

with full section properties:

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 $c_o (5A.5, \text{TBDY}) = 0.002$
Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $c_u = 0.01053874$
 $w_e (5.4c) = 0.03096488$
 $a_s ((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$
 $a_{se1} = 0.16608997$
 $b_o_1 = 170.00$
 $h_o_1 = 170.00$

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

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

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

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

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

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

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

lo/lou,min = lb/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

$y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 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
 $lo/lo_{min} = lb/ld = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
 - $N, 1, 2, v$ normalised to $bo * do$, instead of $b * d$
 - - parameters of confined concrete, fcc, cc , used in lieu of fc, ecu
 --->
 Subcase: Rupture of tension steel
 --->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
 --->
 Subcase rejected
 --->
 New Subcase: Failure of compression zone
 --->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied
 --->

*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu1-

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

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

with full section properties:

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

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

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

Asec = 40000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

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

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

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

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

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

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

and confined core properties:

b = 170.00
d = 157.00
d' = 13.00

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453

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

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

Case/Assumption Rejected.

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

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

c_u (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- N_1, N_2, v normalised to b_o*d_o , instead of $b*d$
- f_{cc}, c_{cc} parameters of confined concrete, f_{cc}, c_{cc} , used in lieu of f_c, c_u

---->
Subcase: Rupture of tension steel

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

Subcase rejected

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

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

* c_u (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

---->
 $u = c_u$ (4.2) = 3.2469244E-005
Mu = MRo

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:

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

with full section properties:

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

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

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

w_e (5.4c) = 0.03096488

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

$a_{se1} = 0.16608997$

$b_{o,1} = 170.00$

$h_{o,1} = 170.00$

$b_{i2,1} = 115600.00$

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

$b_{o,2} = 92.00$

$h_{o,2} = 92.00$

$b_{i2,2} = 33856.00$

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

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

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

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

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

$h_1 = 200.00$

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

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

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

$h_2 = 100.00$

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

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

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

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

$h_1 = 200.00$

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

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

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

$h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

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

c = confinement factor = 1.06329

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

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

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

$su_1 = 0.4 * e_{su1, \text{nominal}}$ ((5.5), TBDY) = 0.032

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

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

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

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

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

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

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

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

$su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2_nominal = 0.08$,
 For calculation of $esu_2_nominal$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl,com,jacket + fs_{core} * Asl,com,core) / Asl,com = 694.45$
 with $Es_2 = (Es_{jacket} * Asl,com,jacket + Es_{core} * Asl,com,core) / Asl,com = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fs_v = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_v = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * Asl,mid,jacket + fs_{mid} * Asl,mid,core) / Asl,mid = 694.45$
 with $Es_v = (Es_{jacket} * Asl,mid,jacket + Es_{mid} * Asl,mid,core) / Asl,mid = 200000.00$
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = Asl,mid / (b * d) * (fs_v / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl,ten / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = Asl,com / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = Asl,mid / (b * d) * (fs_v / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
 - $N, 1, 2, v$ normalised to $bo * do$, instead of $b * d$
 - f_c, c_c parameters of confined concrete, fcc, cc , used in lieu of fc, ec
 --->
 Subcase: Rupture of tension steel
 --->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

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

Calculation of ratio lb/ld

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

Calculation of Mu2-

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

with full section properties:

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

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

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

Ash2 = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

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

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

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

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

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

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

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

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

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

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

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

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

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

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

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

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

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

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

lo/lou,min = lb/d = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

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

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

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

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

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

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

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

and confined core properties:

b = 170.00

d = 157.00

$d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.77530517$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.77530517$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: 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, ec_u
 --->
 Subcase: Rupture of tension steel
 --->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
 --->
 Subcase rejected
 --->
 New Subcase: Failure of compression zone
 --->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied
 --->
 $*cu (4.12) = 0.51649622$
 $MRO (4.16) = 1.3727E+008$
 --->
 $u = cu (4.2) = 3.2469244E-005$
 $Mu = MRO$

 Calculation of ratio l_b/d

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

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

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$
 $V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{Co10}$
 $V_{Co10} = 200506.935$
 $knl = 1$ (zero step-static loading)

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

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

Calculation of Shear Strength at edge 2, $V_{r2} = 200506.935$
 $V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$
 $V_{\text{Col}0} = 200506.935$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_{s1} + f \cdot V_f$ '
 where V_f is the contribution of FRPs (11.3), ACI 440).

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

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

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

Constant Properties

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

Stepwise Properties

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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^* u = 0.04304225$
 $u = y + p = 0.04304225$

- Calculation of y -

$$y = (M_y * L_s / 3) / E_{eff} = 0.03854669 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.0142E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 1500.00$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.3155E+012$$

$$\text{factor} = 0.36543691$$

$$A_g = 40000.00$$

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

$$N = 218376.72$$

$$E_c * I_g = E_{c,\text{jacket}} * I_{g,\text{jacket}} + E_{c,\text{core}} * I_{g,\text{core}} = 3.5999E+012$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

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

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

with $f_y = 555.56$

$$d = 172.00$$

$$y = 0.48055007$$

$$A = 0.10713558$$

$$B = 0.06707136$$

$$\text{with } p_t = 0.02858484$$

$$p_c = 0.02858484$$

$$p_v = 0.03853931$$

$$N = 218376.72$$

$$b = 200.00$$

$$" = 0.1627907$$

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

with $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.48735376$$

$$A = 0.08128164$$

$$B = 0.05564476$$

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

Calculation of ratio l_b/d

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

- Calculation of p -

From table 10-8: $p = 0.00449557$

with:

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

$$\text{shear control ratio } V_y E / V_c O E = 0.4563967$$

$$d = d_{\text{external}} = 172.00$$

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

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_{fe} / f_s) = 0.00885929$$

$$\text{jacket: } s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00785398$$

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

$$h_1 = 200.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00100531$$

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

$$h2 = 100.00$$

$$s2 = 250.00$$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength. All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$NUD = 218376.72$$

$$A_g = 40000.00$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 33.00$$

$$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$$

$$f_{ytE} = (f_{y_ext_Trans_Reinf} \cdot s1 + f_{y_int_Trans_Reinf} \cdot s2) / (s1 + s2) = 555.56$$

$$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.09570899$$

$$b = 200.00$$

$$d = 172.00$$

$$f_{cE} = 33.00$$

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

At local axis: 2

Integration Section: (a)

Calculation No. 3

column C1, Floor 1

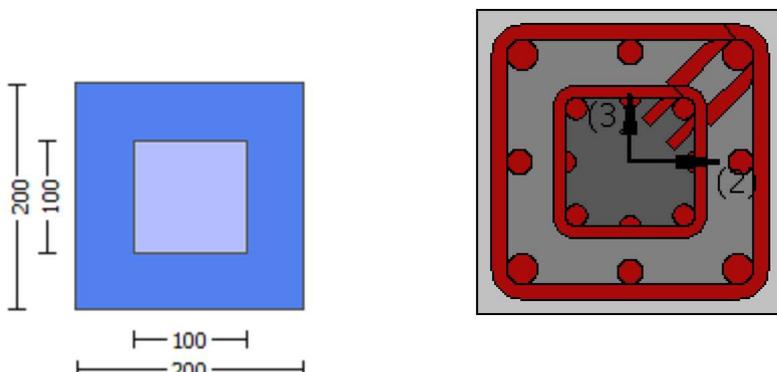
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: Start

Local Axis: (3)



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

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

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

Shear Force, $V_a = 4.1944085E-011$

EDGE -B-

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

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

BOTH EDGES

Axial Force, $F = -218376.72$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 2001.195$

-Compression: $As_c = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

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

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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 * V_n = 177661.069$

$V_n ((10.3), ASCE 41-17) = knl * V_{CoIO} = 177661.069$

$V_{CoI} = 177661.069$

knl = 1.00
displacement_ductility_demand = 0.00

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

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 6.6699040E-008$

$\nu_u = 4.1944085E-011$

$d = 0.8 \cdot h = 160.00$

$N_u = 218376.72$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 3.125$

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

From (11-11), ACI 440: $V_s + V_f \leq 106288.613$

$b_w = 200.00$

displacement_ductility_demand is calculated as ϕ / y

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

From analysis, chord rotation $\theta = 2.0709479E-018$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.03854669$ ((4.29), Biskinis Phd))

$M_y = 1.0142E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.3155E+012$

factor = 0.36543691

$A_g = 40000.00$

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

$N = 218376.72$

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

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

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

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

with $f_y = 555.56$

$d = 172.00$

$y = 0.48055007$

$A = 0.10713558$

$B = 0.06707136$

with $p_t = 0.02858484$

pc = 0.02858484
pv = 0.03853931
N = 218376.72
b = 200.00
" = 0.1627907
y_comp = 2.6245742E-005
with fc = 33.00
Ec = 26999.444
y = 0.48735376
A = 0.08128164
B = 0.05564476
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 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

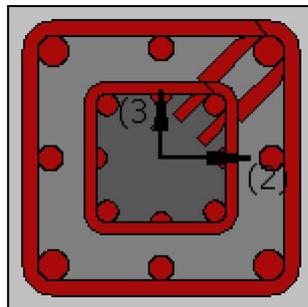
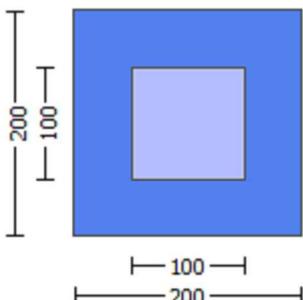
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (3)



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

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\phi = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

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

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

Stepwise Properties

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

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

$$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3727E+008$$

$M_{u2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination

$M_{u2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of M_{u1+}

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

$$\phi_u = 3.2469244E-005$$

$$M_u = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

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

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

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

$$\omega_e \text{ (5.4c)} = 0.03096488$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.16608997$$

$$\text{ase}_1 = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

 $A_{sec} = 40000.00$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

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.

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

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

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

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

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

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

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

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

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 35.08866$$

$$cc (5A.5, TBDY) = 0.00263293$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < vs,y2$ - LHS eq.(4.5) is not satisfied

---->

$v < vs,c$ - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

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

--->

$v < s_y1$ - LHS eq.(4.7) is not satisfied

--->

$v < v_c y1$ - RHS eq.(4.6) is satisfied

--->

c_u (4.10) = 0.45915168

MRC (4.17) = 1.5179E+008

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o , d_o , d'_o
- N_1 , N_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 , c_u

--->

Subcase: Rupture of tension steel

--->

$v^* < v^* s_y2$ - LHS eq.(4.5) is not satisfied

--->

$v^* < v^* s_c$ - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^* c_y2$ - LHS eq.(4.6) is satisfied

--->

c_u (4.12) = 0.51649622

MRO (4.16) = 1.3727E+008

--->

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

$\mu_u = MRO$

Calculation of ratio l_b/d

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

Calculation of μ_{u1} -

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

$u = 3.2469244E-005$

$\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

c_o (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$

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

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

w_e (5.4c) = 0.03096488

$a_s e$ ((5.4d), TBDY) = $(a_{s1} * A_{ext} + a_{s2} * A_{int}) / A_{sec} = 0.16608997$

$a_{s1} = 0.16608997$

$b_{o1} = 170.00$

ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

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

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

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

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

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

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

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

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

y1, sh1,ft1,fy1, are also multiplied by 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 $E_{s2} = (E_{s,jacket} \cdot A_{s1,com,jacket} + E_{s,core} \cdot A_{s1,com,core}) / A_{s1,com} = 200000.00$

$y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$

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
 $lo/lo_{u,min} = lb/ld = 1.00$
 $suv = 0.4 \cdot esuv_{nominal}((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fs_yv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fsv = (f_{s,jacket} \cdot A_{s1,mid,jacket} + f_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 694.45$
with $E_{sv} = (E_{s,jacket} \cdot A_{s1,mid,jacket} + E_{s,mid} \cdot A_{s1,mid,core}) / A_{s1,mid} = 200000.00$

$1 = A_{s1,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.60153764$
 $2 = A_{s1,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.60153764$
 $v = A_{s1,mid} / (b \cdot d) \cdot (fsv / fc) = 0.8110188$

and confined core properties:

$b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc(5A.2, TBDY) = 35.08866$
 $cc(5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s1,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.77530517$
 $2 = A_{s1,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.77530517$
 $v = A_{s1,mid} / (b \cdot d) \cdot (fsv / fc) = 1.0453$

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

--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)

--->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
--->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
--->
 $cu(4.10) = 0.45915168$
 $MRC(4.17) = 1.5179E+008$
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- $N, 1, 2, v$ normalised to $b_o \cdot d_o$, instead of $b \cdot d$
- f_{cc}, c_c 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 satisfied

--->

*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

--->

u = cu (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu₂₊

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

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

with full section properties:

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

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

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

Asec = 40000.00
s1 = 100.00

$s_2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$
 From ((5.A.5), TBDY), TBDY: $cc = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/d = 1.00$
 $su_1 = 0.4 * esu_1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_1_nominal = 0.08$,
 For calculation of $esu_1_nominal$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_1 = (fs_{jacket} * Asl, ten, jacket + fs_{core} * Asl, ten, core) / Asl, ten = 694.45$
 with $Es_1 = (Es_{jacket} * Asl, ten, jacket + Es_{core} * Asl, ten, core) / Asl, ten = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/lb, min = 1.00$
 $su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2_nominal = 0.08$,
 For calculation of $esu_2_nominal$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl, com, jacket + fs_{core} * Asl, com, core) / Asl, com = 694.45$
 with $Es_2 = (Es_{jacket} * Asl, com, jacket + Es_{core} * Asl, com, core) / Asl, com = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$
 $lo/lou, min = lb/d = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl, mid, jacket + fs_{mid} * Asl, mid, core) / Asl, mid = 694.45$
 with $Es_v = (Es_{jacket} * Asl, mid, jacket + Es_{mid} * Asl, mid, core) / Asl, mid = 200000.00$
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.60153764$
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.60153764$
 $v = Asl, mid / (b * d) * (fsv / f_c) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl, ten / (b * d) * (fs_1 / f_c) = 0.77530517$
 $2 = Asl, com / (b * d) * (fs_2 / f_c) = 0.77530517$

$$v = A_{sl, mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 1.0453$$

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

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

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

--->
Case/Assumption Rejected.

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

--->
 $v < v_{s, y1}$ - LHS eq.(4.7) is not satisfied

--->
 $v < v_{c, y1}$ - RHS eq.(4.6) is satisfied

--->
 ρ_{cu} (4.10) = 0.45915168
 M_{Rc} (4.17) = 1.5179E+008

--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o , d_o , d'_o
- N_1 , N_2 , v normalised to $b_o \cdot d_o$, instead of $b \cdot d$
- ρ_{cc} , ρ_{cc} parameters of confined concrete, f_{cc} , ρ_{cc} , used in lieu of f_c , ρ_{cu}

--->
Subcase: Rupture of tension steel

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

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

--->
Subcase rejected

--->
New Subcase: Failure of compression zone

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

--->
 ρ^*_{cu} (4.12) = 0.51649622
 M_{Ro} (4.16) = 1.3727E+008

--->
 $u = \rho_{cu}$ (4.2) = 3.2469244E-005
 $M_u = M_{Ro}$

Calculation of ratio l_b/d

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

Calculation of M_{u2}

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

with full section properties:
 $b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 ρ_{cc} (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01053874$
 we (5.4c) = 0.03096488
 ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
 $ase1 = 0.16608997$
 $bo_1 = 170.00$
 $ho_1 = 170.00$
 $bi2_1 = 115600.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 6.15233$

 $psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 6.15233$
 $ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

 $psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 6.15233$
 $ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

 $A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$

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

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

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

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

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

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

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

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

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

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

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

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

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsv = fs_v/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsv = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_v = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = A_{sl,mid} / (b * d) * (fs_v / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = A_{sl,mid} / (b * d) * (fs_v / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 ---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 ---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 ---->
 Case/Assumption Rejected.
 ---->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 ---->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
 ---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 ---->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 ---->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
 - $N, 1, 2, v$ normalised to $bo * do$, instead of $b * d$
 - f_c, c_c parameters of confined concrete, fcc, cc , used in lieu of fc, ecu
 ---->
 Subcase: Rupture of tension steel
 ---->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 ---->

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

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

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

--->

ϕ_{cu} (4.12) = 0.51649622

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

--->

$u = \phi_{cu}$ (4.2) = 3.2469244E-005

$\mu_u = M_{Ro}$

Calculation of ratio l_b/l_d

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

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

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

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

$V_{Co10} = 200506.935$

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

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

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

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$V_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

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

where:

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

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

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

$b_w = 200.00$

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

$V_{r2} = V_{Co2}$ ((10.3), ASCE 41-17) = $k_{nl} \cdot V_{Co20}$

$V_{Co20} = 200506.935$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$V_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

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

where:

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

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

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

$b_w = 200.00$

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

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

Constant Properties

Knowledge Factor, = 1.00

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

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

Stepwise Properties

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

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

Calculation of μ_{u1+}

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

with full section properties:

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

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

$$\text{Final value of } c_u = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$$

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

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

$$w_e (5.4c) = 0.03096488$$

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

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

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

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

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

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

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

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

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

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

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

--->
Subcase rejected

--->
New Subcase: Failure of compression zone

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

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

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

Calculation of ratio l_b/l_d

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

Calculation of Mu1-

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

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

with full section properties:

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

$f_c = 33.00$

co (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$

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

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

w_e (5.4c) = 0.03096488

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

$ase1 = 0.16608997$

$bo_1 = 170.00$

$ho_1 = 170.00$

$bi2_1 = 115600.00$

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

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi2_2 = 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$

 $psh_x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$

$ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h1 = 200.00$

$ps2$ (internal) = $(A_{sh2} * h2 / s2) / A_{sec} = 0.00100531$

$A_{sh2} = A_{stir_2} * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

$h2 = 100.00$

 $psh_y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$

$ps1$ (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir_1} * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

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

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

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

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

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

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

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

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

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

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

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

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

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

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

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

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

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

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

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

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

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

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

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

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

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

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

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

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

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

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

and confined core properties:

```

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

Calculation of ratio lb/d
-----

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

Calculation of Mu2+
-----
-----

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

```

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$$

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

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

$$w_e (5.4c) = 0.03096488$$

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

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

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

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

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

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

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

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

$y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 1.00$
 $su_2 = 0.4*esu_2,nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2,nominal = 0.08$,
 For calculation of $esu_2,nominal$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45$
 with $Es_2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 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.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$
 with $Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$
 $1 = Asl,ten/(b*d)*(fs_1/fc) = 0.60153764$
 $2 = Asl,com/(b*d)*(fs_2/fc) = 0.60153764$
 $v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl,ten/(b*d)*(fs_1/fc) = 0.77530517$
 $2 = Asl,com/(b*d)*(fs_2/fc) = 0.77530517$
 $v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y_2$ - LHS eq.(4.5) is not satisfied
 --->
 $v < vs,c$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < s,y_1$ - LHS eq.(4.7) is not satisfied
 --->
 $v < vc,y_1$ - RHS eq.(4.6) is satisfied
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 ' In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

--->

Subcase: Rupture of tension steel

--->

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

--->

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

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

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

--->

*cu (4.12) = 0.51649622

MRo (4.16) = 1.3727E+008

--->

u = cu (4.2) = 3.2469244E-005

Mu = MRo

 Calculation of ratio lb/d

 Adequate Lap Length: lb/d >= 1

 Calculation of Mu2-

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

u = 3.2469244E-005

Mu = 1.3727E+008

 with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

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

From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997

ase1 = 0.16608997

bo_1 = 170.00

ho_1 = 170.00

bi2_1 = 115600.00

ase2 = Max(ase1,ase2) = 0.16608997

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

 psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398

Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 200.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns₂ = 2.00
h₂ = 100.00

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 6.15233
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00785398
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 200.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00100531
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 100.00

Asec = 40000.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.45

fywe₂ = 694.45

fce = 33.00

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

c = confinement factor = 1.06329

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 833.34

fy₁ = 694.45

su₁ = 0.032

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

lo/lou,min = lb/l_d = 1.00

su₁ = 0.4*esu_{1_nominal} ((5.5), TBDY) = 0.032

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

For calculation of esu_{1_nominal} and y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

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

with fs₁ = (fs_{jacket}*Asl_{ten,jacket} + fs_{core}*Asl_{ten,core})/Asl_{ten} = 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/l_{b,min} = 1.00

su₂ = 0.4*esu_{2_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{2_nominal} = 0.08,

For calculation of esu_{2_nominal} and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

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

with fs₂ = (fs_{jacket}*Asl_{com,jacket} + fs_{core}*Asl_{com,core})/Asl_{com} = 694.45

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

y_v = 0.0025

sh_v = 0.008

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

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

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.60153764$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.60153764$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

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

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.77530517$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.77530517$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

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

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

Case/Assumption Rejected.

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

$\alpha_{cu} (4.10) = 0.45915168$

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

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o

- $N, 1, 2, v$ normalised to $b_o \cdot d_o$, instead of $b \cdot d$

- f_{cc}, cc parameters of confined concrete, f_{cc}, cc , used in lieu of f_c, α_{cu}

Subcase: Rupture of tension steel

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

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

Subcase rejected

New Subcase: Failure of compression zone

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

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

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

$u = \alpha_{cu} (4.2) = 3.2469244E-005$

$\mu = M_{Ro}$

Calculation of ratio lb/d

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

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

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

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

$V_{\text{Col}0} = 200506.935$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

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

where:

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

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

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

$s/d = 3.125$

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

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

$b_w = 200.00$

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

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} * V_{\text{Col}0}$

$V_{\text{Col}0} = 200506.935$

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

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

$= 1$ (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

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

where:

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

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

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

$s/d = 0.625$

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

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

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

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

Constant Properties

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

Stepwise Properties

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

-Tension: $Asl,ten,jacket = 829.3805$

-Compression: $Asl,com,jacket = 829.3805$

-Middle: $Asl,mid,jacket = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl,ten,core = 153.938$

-Compression: $Asl,com,core = 153.938$

-Middle: $Asl,mid,core = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 17.50$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^*$ $u = 0.0951299$

$u = y + p = 0.0951299$

- Calculation of y -

$y = (My*Ls/3)/Eleff = 0.09063433$ ((4.29),Biskinis Phd))

$My = 1.0142E+008$

$Ls = M/V$ (with $Ls > 0.1*L$ and $Ls < 2*L$) = 3526.931

From table 10.5, ASCE 41_17: $Eleff = factor*Ec*lg = 1.3155E+012$

factor = 0.36543691

$Ag = 40000.00$

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

$N = 218376.72$

$Ec*lg = Ec_jacket*lg_jacket + Ec_core*lg_core = 3.5999E+012$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

$y_{ten} = 3.1090581E-005$

with $fy = 555.56$

$d = 172.00$

$y = 0.48055007$

$A = 0.10713558$

$B = 0.06707136$

with $pt = 0.02858484$

$pc = 0.02858484$

$pv = 0.03853931$

$N = 218376.72$

$b = 200.00$

$" = 0.1627907$

$y_{comp} = 2.6245742E-005$

with $fc = 33.00$

$Ec = 26999.444$

$y = 0.48735376$

$A = 0.08128164$

$B = 0.05564476$

with $Es = 200000.00$

Calculation of ratio lb/d

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

- Calculation of p -

From table 10-8: $p = 0.00449557$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/d \geq 1$
shear control ratio $VyE/VCoIE = 0.4563967$

$$d = d_{\text{external}} = 172.00$$

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

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00885929$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00785398$$

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

$$h_1 = 200.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00100531$$

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

$$h_2 = 100.00$$

$$s_2 = 250.00$$

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

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

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

For the normalisation f_s of jacket is used.

$$N_{UD} = 218376.72$$

$$A_g = 40000.00$$

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

$$f_{yIE} = (f_{y, \text{ext_Long_Reinf}} \cdot A_{\text{ext_Long_Reinf}} + f_{y, \text{int_Long_Reinf}} \cdot A_{\text{int_Long_Reinf}}) / A_{\text{Tot_Long_Rein}} = 555.56$$

$$f_{yIE} = (f_{y, \text{ext_Trans_Reinf}} \cdot s_1 + f_{y, \text{int_Trans_Reinf}} \cdot s_2) / (s_1 + s_2) = 555.56$$

$$\rho_l = A_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.09570899$$

$$b = 200.00$$

$$d = 172.00$$

$$f_{cE} = 33.00$$

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

At local axis: 3

Integration Section: (a)

Calculation No. 5

column C1, Floor 1

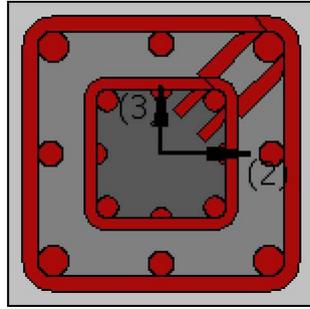
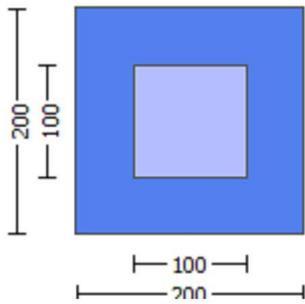
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity 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, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

EDGE -A-

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

Shear Force, $V_a = -31530.033$

EDGE -B-

Bending Moment, $M_b = -6.2875E+006$

Shear Force, $V_b = 31530.033$

BOTH EDGES

Axial Force, $F = -218376.72$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 983.3185$

-Compression: $A_{sc,com} = 983.3185$

-Middle: $A_{st,mid} = 1325.752$

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

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

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col0} = 177661.069$

$V_{Col} = 177661.069$

$k_n = 1.00$

$displacement_ductility_demand = 1.81332$

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)

$M/Vd = 2.00$

$M_u = 6.2875E+006$

$V_u = 31530.033$

$d = 0.8 \cdot h = 160.00$

$N_u = 218376.72$

$A_g = 40000.00$

From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

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

$s/d = 0.625$

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

$d = 80.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

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

$s/d = 3.125$

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

From ((11-11), ACI 440: $V_s + V_f \leq 106288.613$

$bw = 200.00$

$displacement_ductility_demand$ is calculated as ϕ / y

- Calculation of ϕ / y for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation = 0.01397951

$y = (M_y \cdot L_s / 3) / E_{eff} = 0.00770934$ ((4.29), Biskinis Phd))

$M_y = 1.0142E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.3155E+012$

factor = 0.36543691

Ag = 40000.00

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

N = 218376.72

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

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

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

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

with $f_y = 555.56$

d = 172.00

y = 0.48055007

A = 0.10713558

B = 0.06707136

with pt = 0.02858484

pc = 0.02858484

pv = 0.03853931

N = 218376.72

b = 200.00

" = 0.1627907

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

with $f_c = 33.00$

$E_c = 26999.444$

y = 0.48735376

A = 0.08128164

B = 0.05564476

with $E_s = 200000.00$

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

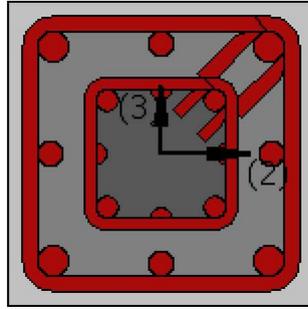
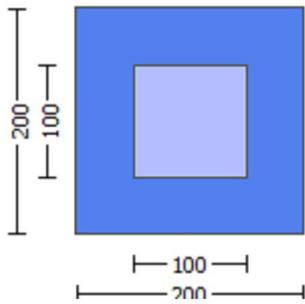
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (2)



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

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

Constant Properties

Knowledge Factor, $\gamma = 1.00$

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

Consequently:

Jacket

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

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

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

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

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

Jacket

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

Existing Column

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

#####

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

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

Longitudinal Bars With Ends Lapped Starting at the End Sections

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

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

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

EDGE -B-

Shear Force, $V_b = 8.1187678E-030$

BOTH EDGES

Axial Force, $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

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

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

-Middle: $As_{mid} = 1325.752$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.4563967$

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

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$

$Mu_{1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

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

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

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

Calculation of Mu_{1+}

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

$\phi_u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

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

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

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

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.16608997$

$ase_1 = 0.16608997$

$bo_1 = 170.00$

$ho_1 = 170.00$

$bi_2_1 = 115600.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.16608997$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi_2_2 = 33856.00$

$psh_{min} * F_{ywe} = \text{Min}(psh_x * F_{ywe}, psh_y * F_{ywe}) = 6.15233$

$psh_x * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 6.15233$

ps_1 (external) = $(Ash_1 * h_1 / s_1) / A_{sec} = 0.00785398$

$Ash_1 = Astir_1 * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h_1 = 200.00$

ps_2 (internal) = $(Ash_2 * h_2 / s_2) / A_{sec} = 0.00100531$

$Ash_2 = Astir_2 * ns_2 = 100.531$

No stirups, $ns_2 = 2.00$

h2 = 100.00

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

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

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

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

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

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

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

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

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

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

```

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < sy1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
--->
v* < v*s,c - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
--->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
--->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

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

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

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

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

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

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

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

$$\text{ase1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

$$\text{psh}_{x} * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 6.15233$$

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

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

No stirups, $n_{s_1} = 2.00$

$$h_1 = 200.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

No stirups, $n_{s_2} = 2.00$

$$h_2 = 100.00$$

$$\text{psh}_{y} * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 6.15233$$

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

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

No stirups, $n_{s_1} = 2.00$

$$h_1 = 200.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

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

No stirups, $n_{s_2} = 2.00$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

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

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

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

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

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

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

with $fs1 = (fs_{jacket} * Asl_{ten,jacket} + fs_{core} * Asl_{ten,core}) / Asl_{ten} = 694.45$

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

$y2 = 0.0025$

$sh2 = 0.008$

$ft2 = 833.34$

$fy2 = 694.45$

$su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the $shear_factor$ according to 15.7.1.4, with

$Shear_factor = 1.00$

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

$su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$

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

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

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

with $fs2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 694.45$

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

$yv = 0.0025$

$shv = 0.008$

$ftv = 833.34$

$fyv = 694.45$

$suv = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with $shear_factor$

and also multiplied by the $shear_factor$ according to 15.7.1.4, with

$Shear_factor = 1.00$

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

$suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$

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

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

For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered

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

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

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

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

$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.60153764$

$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.60153764$

$v = Asl_{mid} / (b * d) * (fsv / fc) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

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

$1 = Asl_{ten} / (b * d) * (fs1 / fc) = 0.77530517$

$2 = Asl_{com} / (b * d) * (fs2 / fc) = 0.77530517$

$v = Asl_{mid} / (b * d) * (fsv / fc) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < vs, y2$ - LHS eq.(4.5) is not satisfied

--->

$v < vs, c$ - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

$v < s, y1$ - LHS eq.(4.7) is not satisfied

--->

$v < vc, y1$ - RHS eq.(4.6) is satisfied

```

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

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

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

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

with full section properties:

```

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

```

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 100.00$$

$$psh_y \cdot Fywe = psh1 \cdot Fywe1 + ps2 \cdot Fywe2 = 6.15233$$

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

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

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

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

$$h2 = 100.00$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

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

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

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

$$lo/lou, \text{min} = lb/ld = 1.00$$

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

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.

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 1.00$$

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

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

$$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$$

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

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

For calculation of $e_{suv_nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered

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

γ_1 , sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

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

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.60153764$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.60153764$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 35.08866$$

$$cc (5A.5, TBDY) = 0.00263293$$

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

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.77530517$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.77530517$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

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

---->

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

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->

$v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied

---->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->

$$c_u (4.10) = 0.45915168$$

$$MR_c (4.17) = 1.5179E+008$$

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b , d , d' replaced by geometric parameters of the core: b_o , d_o , d'_o

- N_1 , N_2 , v normalised to $b_o * d_o$, instead of $b * d$

- 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 satisfied

---->

$$^*c_u (4.12) = 0.51649622$$

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

---->

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

$$\mu_u = MR_o$$

Calculation of ratio l_b/l_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:

$$\mu = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu, c_o) = 0.01053874$$

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

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

$$w_e \text{ (5.4c)} = 0.03096488$$

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

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

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

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

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

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

$$h_1 = 200.00$$

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

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

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

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

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

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

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

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

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

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

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

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

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

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

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

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

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

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

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

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

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

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

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

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

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

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

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

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

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

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 35.08866$$

$$cc (5A.5, TBDY) = 0.00263293$$

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

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

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

$v < s_1 y_1$ - LHS eq.(4.7) is not satisfied

$v < v_c y_1$ - RHS eq.(4.6) is satisfied

ϕ_{cu} (4.10) = 0.45915168

M_{Rc} (4.17) = 1.5179E+008

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- N_1, N_2, v normalised to $b_o d_o$, instead of $b d$
- f_{cc}, f_{cc} parameters of confined concrete, f_{cc}, f_{cc} used in lieu of f_c, e_{cu}

Subcase: Rupture of tension steel

$v^* < v^* s_1 y_2$ - LHS eq.(4.5) is not satisfied

$v^* < v^* s_1 c$ - LHS eq.(4.5) is not satisfied

Subcase rejected

New Subcase: Failure of compression zone

$v^* < v^* c_1 y_2$ - LHS eq.(4.6) is satisfied

ϕ_{cu} (4.12) = 0.51649622

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

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

$\mu_u = M_{Ro}$

Calculation of ratio I_b/I_d

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

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

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

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

$V_{Co10} = 200506.935$

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

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

= 1 (normal-weight concrete)

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

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$V_u = 8.1187678E-030$

$d = 0.8 h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

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

where:

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

$d = 160.00$

$A_v = 157079.633$

fy = 555.56
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.625
Vs2 = 0.00 is calculated for core, with:
d = 80.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 200506.935
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)

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

= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 4.0616465E-011
Vu = 8.1187678E-030
d = 0.8*h = 160.00
Nu = 219397.073
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457
where:
Vs1 = 139627.457 is calculated for jacket, with:
d = 160.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.625
Vs2 = 0.00 is calculated for core, with:
d = 80.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

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

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

Constant Properties

```

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

Stepwise Properties
-----
At local axis: 2
EDGE -A-
Shear Force,  $V_a = -1.9686856E-030$ 
EDGE -B-
Shear Force,  $V_b = 1.9686856E-030$ 
BOTH EDGES
Axial Force,  $F = -219397.073$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
  -Tension:  $A_{st} = 0.00$ 
  -Compression:  $A_{sc} = 3292.389$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
  -Tension:  $A_{st, \text{ten}} = 983.3185$ 
  -Compression:  $A_{st, \text{com}} = 983.3185$ 
  -Middle:  $A_{st, \text{mid}} = 1325.752$ 
-----
-----

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

```

Mu2+ = 1.3727E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

Mu2- = 1.3727E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu1+

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

$$\phi_u = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

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

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

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

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

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

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

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

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

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

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

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

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 35.08866$$

$$cc (5A.5, TBDY) = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->

$v < s_1 y_1$ - LHS eq.(4.7) is not satisfied

---->

$v < v_c y_1$ - RHS eq.(4.6) is satisfied

---->

c_u (4.10) = 0.45915168

M_{Rc} (4.17) = 1.5179E+008

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o , d_o , d'_o
- N , ν_1 , ν_2 , ν 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

---->

$v^* < v^* s_1 y_2$ - LHS eq.(4.5) is not satisfied

---->

$v^* < v^* s_c$ - LHS eq.(4.5) is not satisfied

---->

Subcase rejected

---->

New Subcase: Failure of compression zone

---->

$v^* < v^* c y_2$ - LHS eq.(4.6) is satisfied

---->

c_u (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

---->

$u = c_u$ (4.2) = 3.2469244E-005

$M_u = M_{Ro}$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u1} -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$\nu = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

c_o (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01053874$

w_e (5.4c) = 0.03096488

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$

$a_{se1} = 0.16608997$

$b_{o1} = 170.00$

$h_{o1} = 170.00$

bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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

$y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 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
 $lo/lo_{min} = lb/ld = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fs_v = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Esv = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
 - $N, 1, 2, v$ normalised to $bo * do$, instead of $b * d$
 - - parameters of confined concrete, fcc, cc , used in lieu of fc, ecu
 --->
 Subcase: Rupture of tension steel
 --->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
 --->
 Subcase rejected
 --->
 New Subcase: Failure of compression zone
 --->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied
 --->

$$*cu(4.12) = 0.51649622$$
$$MRo(4.16) = 1.3727E+008$$

--->

$$u = cu(4.2) = 3.2469244E-005$$
$$Mu = MRo$$

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu₂₊

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$
$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$
$$d = 172.00$$
$$d' = 28.00$$
$$v = 0.19326733$$
$$N = 219397.073$$
$$fc = 33.00$$
$$co(5A.5, TBDY) = 0.002$$
$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01053874$$
$$we(5.4c) = 0.03096488$$
$$ase((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997$$
$$ase1 = 0.16608997$$
$$bo_1 = 170.00$$
$$ho_1 = 170.00$$
$$bi2_1 = 115600.00$$
$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$
$$bo_2 = 92.00$$
$$ho_2 = 92.00$$
$$bi2_2 = 33856.00$$
$$psh, \min * Fywe = \text{Min}(psh, x * Fywe, psh, y * Fywe) = 6.15233$$

$$psh_x * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$$
$$ps1(\text{external}) = (Ash1 * h1 / s1) / Asec = 0.00785398$$
$$Ash1 = Astir_1 * ns_1 = 157.0796$$

No stirups, ns₁ = 2.00

$$h1 = 200.00$$
$$ps2(\text{internal}) = (Ash2 * h2 / s2) / Asec = 0.00100531$$
$$Ash2 = Astir_2 * ns_2 = 100.531$$

No stirups, ns₂ = 2.00

$$h2 = 100.00$$

$$psh_y * Fywe = psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$$
$$ps1(\text{external}) = (Ash1 * h1 / s1) / Asec = 0.00785398$$
$$Ash1 = Astir_1 * ns_1 = 157.0796$$

No stirups, ns₁ = 2.00

$$h1 = 200.00$$
$$ps2(\text{internal}) = (Ash2 * h2 / s2) / Asec = 0.00100531$$
$$Ash2 = Astir_2 * ns_2 = 100.531$$

No stirups, ns₂ = 2.00

$$h2 = 100.00$$

$$Asec = 40000.00$$
$$s1 = 100.00$$
$$s2 = 250.00$$

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764

2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764

v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00
d = 157.00
d' = 13.00

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
---->

Case/Assumption Rejected.

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)

---->
 $v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
---->

c_u (4.10) = 0.45915168
 M_{Rc} (4.17) = 1.5179E+008

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- N_1, N_2, v normalised to b_o*d_o , instead of $b*d$
- f_{cc}, c_{cc} parameters of confined concrete, f_{cc}, c_{cc} , used in lieu of f_c, c_u

---->
Subcase: Rupture of tension steel

---->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
---->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
---->

Subcase rejected

---->
New Subcase: Failure of compression zone

---->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied
---->

$*c_u$ (4.12) = 0.51649622
 M_{Ro} (4.16) = 1.3727E+008

---->
 $u = c_u$ (4.2) = 3.2469244E-005
 $M_u = M_{Ro}$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of M_{u2}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$u = 3.2469244E-005$
 $M_u = 1.3727E+008$

with full section properties:

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 c_o (5A.5, TBDY) = 0.002
Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01053874$

w_e (5.4c) = 0.03096488

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$

$a_{se1} = 0.16608997$

$b_{o_1} = 170.00$

$h_{o_1} = 170.00$

$b_{i2_1} = 115600.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 200.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 200.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$A_{sec} = 40000.00$

$s_1 = 100.00$

$s_2 = 250.00$

$f_{ywe1} = 694.45$

$f_{ywe2} = 694.45$

$f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00263293$

c = confinement factor = 1.06329

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_d = 1.00$

$su_1 = 0.4 * e_{su1_nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $e_{su1_nominal} = 0.08$,

For calculation of $e_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $f_{sy1} = f_s / 1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b / l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s1} = (f_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + f_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 694.45$

with $E_{s1} = (E_{s, \text{jacket}} * A_{s1, \text{ten, jacket}} + E_{s, \text{core}} * A_{s1, \text{ten, core}}) / A_{s1, \text{ten}} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$l_o / l_{ou, \min} = l_b / l_{b, \min} = 1.00$

$su_2 = 0.4 * esu_2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_2_nominal = 0.08$,
 For calculation of $esu_2_nominal$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl_{,com,jacket} + fs_{core} * Asl_{,com,core}) / Asl_{,com} = 694.45$
 with $Es_2 = (Es_{jacket} * Asl_{,com,jacket} + Es_{core} * Asl_{,com,core}) / Asl_{,com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 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.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{,mid,jacket} + fs_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 694.45$
 with $Es_v = (Es_{jacket} * Asl_{,mid,jacket} + Es_{mid} * Asl_{,mid,core}) / Asl_{,mid} = 200000.00$
 $1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = Asl_{,mid} / (b * d) * (fs_v / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl_{,ten} / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = Asl_{,com} / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = Asl_{,mid} / (b * d) * (fs_v / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
 - $N, 1, 2, v$ normalised to $bo * do$, instead of $b * d$
 - f_c, c parameters of confined concrete, fcc, cc , used in lieu of fc, ec
 --->
 Subcase: Rupture of tension steel
 --->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

```

---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/ld
-----
Adequate Lap Length: lb/ld >= 1
-----

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 200506.935
-----

Calculation of Shear Strength at edge 1, Vr1 = 200506.935
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)
-----

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-----
= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 2.0213315E-011
Vu = 1.9686856E-030
d = 0.8*h = 160.00
Nu = 219397.073
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457
where:
Vs1 = 139627.457 is calculated for jacket, with:
d = 160.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.625
Vs2 = 0.00 is calculated for core, with:
d = 80.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00
-----

Calculation of Shear Strength at edge 2, Vr2 = 200506.935
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)
-----

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'

```

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$b_w = 200.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -6.0481164E-008$

Shear Force, $V2 = 31530.033$

Shear Force, $V3 = -4.1944085E-011$

Axial Force, $F = -218376.72$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 983.3185$

-Compression: $As_{c,com} = 983.3185$

-Middle: $As_{mid} = 1325.752$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,jacket} = 829.3805$

-Compression: $As_{c,com,jacket} = 829.3805$

-Middle: $As_{mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten,core} = 153.938$

-Compression: $As_{c,com,core} = 153.938$

-Middle: $As_{mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $Db_L = 17.50$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.04304225$

$u = y + p = 0.04304225$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.03854669$ ((4.29), Biskinis Phd))

$M_y = 1.0142E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.3155E+012$

$factor = 0.36543691$

$A_g = 40000.00$

Mean concrete strength: $fc' = (fc'_{jacket} * Area_{jacket} + fc'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 218376.72$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 3.1090581E-005$

with $f_y = 555.56$

$d = 172.00$

$y = 0.48055007$

$A = 0.10713558$

$B = 0.06707136$

with $pt = 0.02858484$

$pc = 0.02858484$

$pv = 0.03853931$

$N = 218376.72$

$b = 200.00$

" = 0.1627907
y_comp = 2.6245742E-005
with fc = 33.00
Ec = 26999.444
y = 0.48735376
A = 0.08128164
B = 0.05564476
with Es = 200000.00

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

- Calculation of p -

From table 10-8: p = 0.00449557

with:

- Columns not controlled by inadequate development or splicing along the clear height because lb/l_d >= 1

shear control ratio $V_y E / V_{CoI} O E = 0.4563967$

d = d_{external} = 172.00

s = s_{external} = 150.00

t = s₁ + s₂ + 2*tf/bw*(ffe/fs) = 0.00885929

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) = 0.00100531

Av₂ = 100.531, is the total area of all stirrups parallel to loading (shear) direction

h₂ = 100.00

s₂ = 250.00

The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution

where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation fs of jacket is used.

NUD = 218376.72

Ag = 40000.00

f_{cE} = (fc_{jacket}*Area_{jacket}+fc_{core}*Area_{core})/section_area = 33.00

f_{yI}E = (fy_{ext}_Long_Reinf*Area_{ext}_Long_Reinf+fy_{int}_Long_Reinf*Area_{int}_Long_Reinf)/Area_Tot_Long_Rein = 555.56

f_{yT}E = (fy_{ext}_Trans_Reinf* s₁+fy_{int}_Trans_Reinf* s₂)/(s₁+ s₂) = 555.56

pl = Area_Tot_Long_Rein/(b*d) = 0.09570899

b = 200.00

d = 172.00

f_{cE} = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 7

column C1, Floor 1

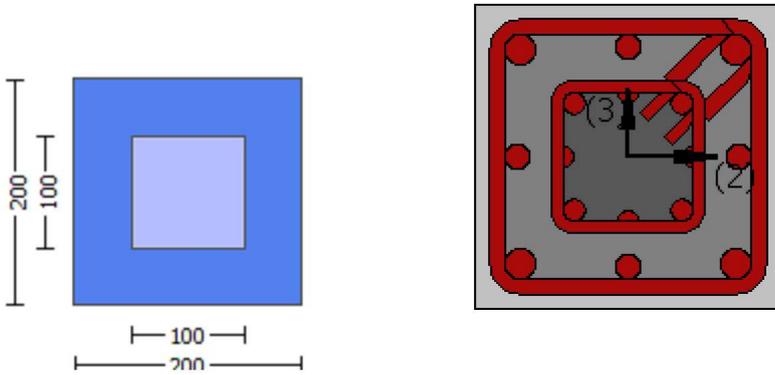
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity 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, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, $M_a = -6.6699040E-008$
Shear Force, $V_a = 4.1944085E-011$
EDGE -B-
Bending Moment, $M_b = -6.0481164E-008$
Shear Force, $V_b = -4.1944085E-011$
BOTH EDGES
Axial Force, $F = -218376.72$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3292.389$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st,ten} = 983.3185$
-Compression: $A_{sl,com} = 983.3185$
-Middle: $A_{sl,mid} = 1325.752$
Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 177661.069$
 V_n ((10.3), ASCE 41-17) = $knI \cdot V_{CoI} = 177661.069$
 $V_{CoI} = 177661.069$
 $knI = 1.00$
 $displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d/s$ ' is replaced by ' $V_{s+} = f \cdot V_f$ '
where V_f is the contribution of FRPs ((11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c,jacket} \cdot Area_{jacket} + f'_{c,core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f'_c^{0.5} \leq 8.3$
MPa ((22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $M_u = 6.0481164E-008$
 $V_u = 4.1944085E-011$
 $d = 0.8 \cdot h = 160.00$
 $N_u = 218376.72$
 $A_g = 40000.00$
From ((11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$
where:
 $V_{s1} = 125663.706$ is calculated for jacket, with:
 $d = 160.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.625$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 3.125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From ((11-11), ACI 440: $V_s + V_f \leq 106288.613$
 $bw = 200.00$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END B -
for rotation axis 2 and integ. section (b)

From analysis, chord rotation = $2.8425018E-018$

$y = (M_y * L_s / 3) / E_{eff} = 0.03854669$ ((4.29), Biskinis Phd)

$M_y = 1.0142E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.3155E+012$

factor = 0.36543691

$A_g = 40000.00$

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$

$N = 218376.72$

$E_c * I_g = E_c * I_{g,jacket} + E_c * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$

$y_{ten} = 3.1090581E-005$

with $f_y = 555.56$

$d = 172.00$

$y = 0.48055007$

$A = 0.10713558$

$B = 0.06707136$

with $p_t = 0.02858484$

$p_c = 0.02858484$

$p_v = 0.03853931$

$N = 218376.72$

$b = 200.00$

" = 0.1627907

$y_{comp} = 2.6245742E-005$

with $f_c = 33.00$

$E_c = 26999.444$

$y = 0.48735376$

$A = 0.08128164$

$B = 0.05564476$

with $E_s = 200000.00$

Calculation of ratio I_b / I_d

Adequate Lap Length: $I_b / I_d \geq 1$

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

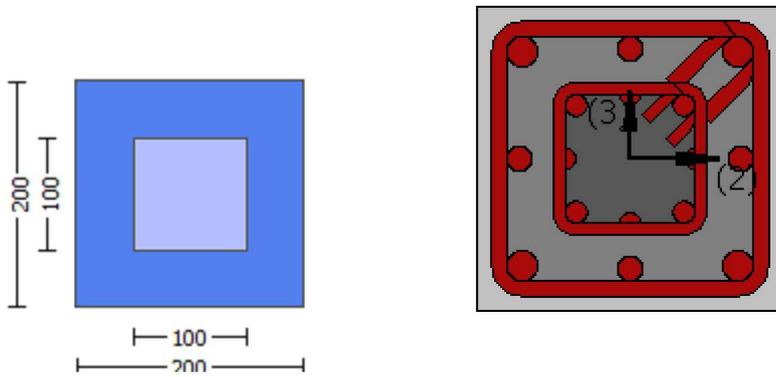
Limit State: Operational Level (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (θ_u)

Edge: End

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou,min} >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -8.1187678E-030$
EDGE -B-
Shear Force, $V_b = 8.1187678E-030$
BOTH EDGES
Axial Force, $F = -219397.073$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3292.389$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 983.3185$
-Compression: $As_{c,com} = 983.3185$
-Middle: $As_{c,mid} = 1325.752$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.4563967$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$
with
 $M_{pr1} = \text{Max}(\mu_{u1+}, \mu_{u1-}) = 1.3727E+008$
 $\mu_{u1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $\mu_{u1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(\mu_{u2+}, \mu_{u2-}) = 1.3727E+008$
 $\mu_{u2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
 $\mu_{u2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

Calculation of μ_{u1+}

Calculation of ultimate curvature μ_u according to 4.1, Biskinis/Fardis 2013:
 $\mu_u = 3.2469244E-005$
 $\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
Final value of μ_u : $\mu_u^* = \text{shear_factor} * \text{Max}(\mu_u, \mu_c) = 0.01053874$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\mu_u = 0.01053874$
 $w_e (5.4c) = 0.03096488$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
 $ase1 = 0.16608997$
 $bo_1 = 170.00$
 $ho_1 = 170.00$
 $bi2_1 = 115600.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$

bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb)^2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by 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/d = 1.00
  suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
  From table 5A.1, TBDY: esuv_nominal = 0.08,
  considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
  For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
  characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
  y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/d)^2/3), from 10.3.5, ASCE 41-17.
  with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
  with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
  1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
  2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
  v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
  c = confinement factor = 1.06329
  1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
  2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
  v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
  cu (4.10) = 0.45915168
  MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
  *cu (4.12) = 0.51649622
  MRo (4.16) = 1.3727E+008

```

--->

$$u = cu(4.2) = 3.2469244E-005$$

$$\mu = M_{Ro}$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_1 -

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o(5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01053874$$

$$w_e(5.4c) = 0.03096488$$

$$a_{se}((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o1} = 170.00$$

$$h_{o1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o2} = 92.00$$

$$h_{o2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s2} = 100.531$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s1} = 157.0796$$

$$\text{No stirups, } n_{s1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s2} = 100.531$$

$$\text{No stirups, } n_{s2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00263293$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \min = lb/ld = 1.00$$

$$su_1 = 0.4 * esu_1 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,

For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{\text{jacket}} * Asl, \text{ten, jacket} + fs_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

$$\text{with } Es_1 = (Es_{\text{jacket}} * Asl, \text{ten, jacket} + Es_{\text{core}} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

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

$$lo/lou, \min = lb/lb, \min = 1.00$$

$$su_2 = 0.4 * esu_2 \text{ nominal } ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,

For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (fs_{\text{jacket}} * Asl, \text{com, jacket} + fs_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

$$\text{with } Es_2 = (Es_{\text{jacket}} * Asl, \text{com, jacket} + Es_{\text{core}} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

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

$$lo/lou, \min = lb/ld = 1.00$$

$$suv = 0.4 * esuv \text{ nominal } ((5.5), \text{TBDY}) = 0.032$$

From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsy_v = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs_{\text{jacket}} * Asl, \text{mid, jacket} + fs_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

$$\text{with } Es_v = (Es_{\text{jacket}} * Asl, \text{mid, jacket} + Es_{\text{mid}} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.60153764$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.60153764$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 35.08866$$

$$cc \text{ (5A.5, TBDY)} = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$1 = Asl, \text{ten} / (b * d) * (fs_1 / fc) = 0.77530517$$

$$2 = Asl, \text{com} / (b * d) * (fs_2 / fc) = 0.77530517$$

$$v = Asl, \text{mid} / (b * d) * (fsv / fc) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008

with full section properties:
b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu* = shear_factor * Max(cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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 = (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 , $sh_{2,ft2,fy2}$, it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , $sh_{1,ft1,fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 694.45$

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 $Shear_factor = 1.00$

$lo/lo_{u,min} = lb/ld = 1.00$

$suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

y_1 , $sh_{1,ft1,fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_v = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 694.45$

with $Es_v = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.60153764$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.60153764$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.77530517$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.77530517$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

Case/Assumption Rejected.

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

$cu (4.10) = 0.45915168$

$MRC (4.17) = 1.5179E+008$

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b , d , d' replaced by geometric parameters of the core: bo , do , $d'o$

- N , 1 , 2 , v normalised to $bo \cdot do$, instead of $b \cdot d$

- f_c , cc parameters of confined concrete, fcc , cc , used in lieu of fc , ecu

Subcase: Rupture of tension steel

$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

Subcase rejected

--->
New Subcase: Failure of compression zone

--->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied

--->
 $*c_u$ (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

--->
 $u = c_u$ (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
 $u = 3.2469244E-005$
Mu = 1.3727E+008

with full section properties:

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073

fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.01053874$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $c_u = 0.01053874$

we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = $\text{Max}(ase1, ase2) = 0.16608997$
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = $\text{Min}(psh,x * Fywe, psh,y * Fywe) = 6.15233$

psh_x*Fywe = $psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
Ash1 = $A_{stir_1} * ns_1 = 157.0796$
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
Ash2 = $A_{stir_2} * ns_2 = 100.531$
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = $psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
Ash1 = $A_{stir_1} * ns_1 = 157.0796$
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
Ash2 = $A_{stir_2} * ns_2 = 100.531$
No stirups, ns_2 = 2.00

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $c_c = 0.00263293$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$lo/lou, \min = lb/l_d = 1.00$$

$$su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,

For calculation of $esu_1 \text{ nominal}$ and y_1 , sh_1 , ft_1 , fy_1 , it is considered characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (f_{s,jacket} * A_{s1,ten,jacket} + f_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 694.45$$

$$\text{with } Es_1 = (E_{s,jacket} * A_{s1,ten,jacket} + E_{s,core} * A_{s1,ten,core}) / A_{s1,ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

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

$$lo/lou, \min = lb/l_{b, \min} = 1.00$$

$$su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,

For calculation of $esu_2 \text{ nominal}$ and y_2 , sh_2 , ft_2 , fy_2 , it is considered characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_2 = (f_{s,jacket} * A_{s2,com,jacket} + f_{s,core} * A_{s2,com,core}) / A_{s2,com} = 694.45$$

$$\text{with } Es_2 = (E_{s,jacket} * A_{s2,com,jacket} + E_{s,core} * A_{s2,com,core}) / A_{s2,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

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

$$lo/lou, \min = lb/l_d = 1.00$$

$$suv = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv \text{ nominal}$ and y_v , sh_v , ft_v , fy_v , it is considered characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1 , sh_1 , ft_1 , fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$$

$$\text{with } Es_v = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s1,ten} / (b * d) * (fs_1 / f_c) = 0.60153764$$

$$2 = A_{s2,com} / (b * d) * (fs_2 / f_c) = 0.60153764$$

$$v = A_{s,mid} / (b * d) * (fsv / f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc \text{ (5A.2, TBDY)} = 35.08866$$

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->
v < vs,y2 - LHS eq.(4.5) is not satisfied

---->
v < vs,c - RHS eq.(4.5) is not satisfied

---->
Case/Assumption Rejected.

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)

---->
v < s,y1 - LHS eq.(4.7) is not satisfied

---->
v < vc,y1 - RHS eq.(4.6) is satisfied

---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

---->
Subcase: Rupture of tension steel

---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied

---->
v* < v*s,c - LHS eq.(4.5) is not satisfied

---->
Subcase rejected

---->
New Subcase: Failure of compression zone

---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied

---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 200506.935

Calculation of Shear Strength at edge 1, Vr1 = 200506.935
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 200506.935$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = k_{nl} \cdot V_{\text{Col}0}$

$V_{\text{Col}0} = 200506.935$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), 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, $\gamma = 1.00$
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$
Existing Column
New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

External Height, $H = 200.00$
External Width, $W = 200.00$
Internal Height, $H = 100.00$
Internal Width, $W = 100.00$
Cover Thickness, $c = 10.00$
Mean Confinement Factor overall section = 1.06329
Element Length, $L = 3000.00$

Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -1.9686856E-030$
EDGE -B-
Shear Force, $V_b = 1.9686856E-030$
BOTH EDGES
Axial Force, $F = -219397.073$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{sl,t} = 0.00$
-Compression: $A_{sl,c} = 3292.389$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{sl,ten} = 983.3185$
-Compression: $A_{sl,com} = 983.3185$
-Middle: $A_{sl,mid} = 1325.752$

Calculation of Shear Capacity ratio , $V_e/V_r = 0.4563967$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(M_{u1+} , M_{u1-}) = 1.3727E+008$

$M_{u1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+} , M_{u2-}) = 1.3727E+008$

$M_{u2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01053874$

w_e (5.4c) = 0.03096488

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$

$a_{se1} = 0.16608997$

$b_{o_1} = 170.00$

$h_{o_1} = 170.00$

$b_{i2_1} = 115600.00$

$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$

$b_{o_2} = 92.00$

$h_{o_2} = 92.00$

$b_{i2_2} = 33856.00$

$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 200.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirups, $n_{s_2} = 2.00$

$h_2 = 100.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$

p_{s1} (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$

No stirups, $n_{s_1} = 2.00$

$h_1 = 200.00$

p_{s2} (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$

No stirrups, $n_s_2 = 2.00$
 $h_2 = 100.00$

Asec = 40000.00

$s_1 = 100.00$

$s_2 = 250.00$

$fy_{we1} = 694.45$

$fy_{we2} = 694.45$

$f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$y_1 = 0.0025$

$sh_1 = 0.008$

$ft_1 = 833.34$

$fy_1 = 694.45$

$su_1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou, \min = lb/ld = 1.00$

$su_1 = 0.4 * esu_1 \text{ nominal ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu_1 \text{ nominal} = 0.08$,

For calculation of $esu_1 \text{ nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_1 = (fs_{jacket} * Asl, \text{ten, jacket} + fs_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$

with $Es_1 = (Es_{jacket} * Asl, \text{ten, jacket} + Es_{core} * Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou, \min = lb/lb, \min = 1.00$

$su_2 = 0.4 * esu_2 \text{ nominal ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esu_2 \text{ nominal} = 0.08$,

For calculation of $esu_2 \text{ nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} * Asl, \text{com, jacket} + fs_{core} * Asl, \text{com, core}) / Asl, \text{com} = 694.45$

with $Es_2 = (Es_{jacket} * Asl, \text{com, jacket} + Es_{core} * Asl, \text{com, core}) / Asl, \text{com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou, \min = lb/ld = 1.00$

$su_v = 0.4 * esuv \text{ nominal ((5.5), TBDY)} = 0.032$

From table 5A.1, TBDY: $esuv \text{ nominal} = 0.08$,

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv \text{ nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fsv = (fs_{jacket} * Asl, \text{mid, jacket} + fs_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$

with $Es_v = (Es_{jacket} * Asl, \text{mid, jacket} + Es_{mid} * Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$

$1 = Asl, \text{ten} / (b * d) * (fs_1 / f_c) = 0.60153764$

$2 = Asl, \text{com} / (b * d) * (fs_2 / f_c) = 0.60153764$

$v = Asl, \text{mid} / (b * d) * (fsv / f_c) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

f_{cc} (5A.2, TBDY) = 35.08866
 cc (5A.5, TBDY) = 0.00263293
 c = confinement factor = 1.06329
 $1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.77530517$
 $2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.77530517$
 $v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.

New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 cu (4.10) = 0.45915168
 M_{Rc} (4.17) = 1.5179E+008
 --->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
 - $N, 1, 2, v$ normalised to b_o*d_o , instead of $b*d$
 - - parameters of confined concrete, f_{cc}, cc , used in lieu of f_c, ec_u

Subcase: Rupture of tension steel
 --->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied
 --->
 Subcase rejected

New Subcase: Failure of compression zone
 --->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied
 --->
 $*cu$ (4.12) = 0.51649622
 M_{Ro} (4.16) = 1.3727E+008
 --->
 $u = cu$ (4.2) = 3.2469244E-005
 $M_u = M_{Ro}$

 Calculation of ratio l_b/d

 Adequate Lap Length: $l_b/d >= 1$

 Calculation of M_{u1} -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 3.2469244E-005$
 $M_u = 1.3727E+008$

 with full section properties:

$b = 200.00$
 $d = 172.00$

$d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = shear_factor * Max(cu, cc) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01053874$
 $w_e (5.4c) = 0.03096488$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
 $ase1 = 0.16608997$
 $bo_1 = 170.00$
 $ho_1 = 170.00$
 $bi2_1 = 115600.00$
 $ase2 = Max(ase1, ase2) = 0.16608997$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, min * F_{ywe} = Min(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$

$psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$
 $ps1 (external) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 (internal) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_c = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00263293$
 $c = confinement\ factor = 1.06329$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $Shear_factor = 1.00$

$lo/lou, min = lb/ld = 1.00$

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu1_nominal = 0.08$,

For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs, jacket * A_{sl, ten, jacket} + fs, core * A_{sl, ten, core}) / A_{sl, ten} = 694.45$

with $Es1 = (Es, jacket * A_{sl, ten, jacket} + Es, core * A_{sl, ten, core}) / A_{sl, ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$

$f_{y2} = 694.45$
 $s_{u2} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $s_{u2} = 0.4 * e_{su2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{su2,nominal} = 0.08$,
 For calculation of $e_{su2,nominal}$ and y_2, sh_2, ft_2, f_{y2} , it is considered
 characteristic value $f_{s2} = f_{s2}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s2} = (f_{s,jacket} * A_{s1,com,jacket} + f_{s,core} * A_{s1,com,core}) / A_{s1,com} = 694.45$
 with $E_{s2} = (E_{s,jacket} * A_{s1,com,jacket} + E_{s,core} * A_{s1,com,core}) / A_{s1,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $f_{y_v} = 694.45$
 $s_{u_v} = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{ou,min} = l_b/l_d = 1.00$
 $s_{u_v} = 0.4 * e_{suv,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $e_{suv,nominal} = 0.08$,
 considering characteristic value $f_{s_v} = f_{s_v}/1.2$, from table 5.1, TBDY
 For calculation of $e_{suv,nominal}$ and y_v, sh_v, ft_v, f_{y_v} , it is considered
 characteristic value $f_{s_v} = f_{s_v}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, f_{y1} , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $f_{s_v} = (f_{s,jacket} * A_{s1,mid,jacket} + f_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 694.45$
 with $E_{s_v} = (E_{s,jacket} * A_{s1,mid,jacket} + E_{s,mid} * A_{s1,mid,core}) / A_{s1,mid} = 200000.00$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.60153764$
 $2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.60153764$
 $v = A_{s1,mid} / (b * d) * (f_{s_v} / f_c) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s1,ten} / (b * d) * (f_{s1} / f_c) = 0.77530517$
 $2 = A_{s1,com} / (b * d) * (f_{s2} / f_c) = 0.77530517$
 $v = A_{s1,mid} / (b * d) * (f_{s_v} / f_c) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 $c_u (4.10) = 0.45915168$
 $M_{Rc} (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
 - $N, 1, 2, v$ normalised to $b_o * d_o$, instead of $b * d$
 - 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 satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

```

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073
fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of cu: cu* = shear_factor * Max( cu, cc) = 0.01053874
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: cu = 0.01053874
we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

```

```

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

```

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 6.15233
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00785398
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 200.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00100531
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 100.00

Asec = 40000.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.45

fywe₂ = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 833.34

fy₁ = 694.45

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su₁ = 0.4*esu_{1_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{1_nominal} = 0.08,

For calculation of esu_{1_nominal} and 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*esu_{2_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{2_nominal} = 0.08,

For calculation of esu_{2_nominal} and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/ld)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs_{jacket}*Asl_{com,jacket} + fs_{core}*Asl_{com,core})/Asl_{com} = 694.45

with Es₂ = (Es_{jacket}*Asl_{com,jacket} + Es_{core}*Asl_{com,core})/Asl_{com} = 200000.00

y_v = 0.0025

sh_v = 0.008

ft_v = 833.34

fy_v = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

suv = 0.4*esuv_{nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_{nominal} = 0.08,

considering characteristic value fsy_v = fs_v/1.2, from table 5.1, TBDY

For calculation of esuv_{nominal} and y_v, sh_v,ft_v,fy_v, it is considered
characteristic value fsy_v = fs_v/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 fs_v = (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

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.60153764$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.60153764$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 35.08866$$

$$c_c (5A.5, TBDY) = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$1 = A_{s1,ten}/(b*d)*(f_{s1}/f_c) = 0.77530517$$

$$2 = A_{s2,com}/(b*d)*(f_{s2}/f_c) = 0.77530517$$

$$v = A_{s,mid}/(b*d)*(f_{sv}/f_c) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->

$v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied

---->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->

$$c_u (4.10) = 0.45915168$$

$$M_{Rc} (4.17) = 1.5179E+008$$

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- N_1, N_2, v normalised to b_o*d_o , instead of $b*d$
- parameters of confined concrete, f_{cc}, c_c , used in lieu of f_c, c_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 satisfied

---->

$$*c_u (4.12) = 0.51649622$$

$$M_{Ro} (4.16) = 1.3727E+008$$

---->

$$u = c_u (4.2) = 3.2469244E-005$$

$$M_u = M_{Ro}$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of M_{u2} -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_u = 0.01053874$$

$$w_e(5.4c) = 0.03096488$$

$$a_{se}((5.4d), \text{TBDY}) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } \phi_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}}((5.5), \text{TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1, \text{nominal}} = 0.08,$$

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered

characteristic value $f_{s1} = f_s/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s1} = (f_{s,jacket} \cdot A_{s,ten,jacket} + f_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 694.45$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core})/A_{s,ten} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$

$ft_2 = 833.34$

$fy_2 = 694.45$

$su_2 = 0.032$

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

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$

$su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,

For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered

characteristic value $f_{s2} = f_s/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 694.45$

with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$fy_v = 694.45$

$su_v = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,

considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.45$

with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.60153764$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.60153764$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.77530517$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.77530517$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{sv}/f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

---->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->

$cu (4.10) = 0.45915168$

MRC (4.17) = 1.5179E+008

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

---->

Subcase: Rupture of tension steel

---->

$v^* < v^*s,y2$ - LHS eq.(4.5) is not satisfied

---->

$v^* < v^*s,c$ - LHS eq.(4.5) is not satisfied

---->

Subcase rejected

---->

New Subcase: Failure of compression zone

---->

$v^* < v^*c,y2$ - LHS eq.(4.6) is satisfied

---->

*cu (4.12) = 0.51649622

MRO (4.16) = 1.3727E+008

---->

u = cu (4.2) = 3.2469244E-005

Mu = MRO

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 200506.935

Calculation of Shear Strength at edge 1, Vr1 = 200506.935

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 200506.935

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.0213315E-011

Vu = 1.9686856E-030

d = 0.8*h = 160.00

Nu = 219397.073

Ag = 40000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457

where:

Vs1 = 139627.457 is calculated for jacket, with:

d = 160.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.625

Vs2 = 0.00 is calculated for core, with:

d = 80.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 200506.935
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*VF'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 2.0213315E-011
Vu = 1.9686856E-030
d = 0.8*h = 160.00
Nu = 219397.073
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457

where:
Vs1 = 139627.457 is calculated for jacket, with:
d = 160.00
Av = 157079.633
fy = 555.56
s = 100.00

Vs1 is multiplied by Col1 = 1.00
s/d = 0.625

Vs2 = 0.00 is calculated for core, with:
d = 80.00
Av = 100530.965
fy = 555.56
s = 250.00

Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -6.2875E+006$

Shear Force, $V_2 = 31530.033$

Shear Force, $V_3 = -4.1944085E-011$

Axial Force, $F = -218376.72$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 0.00$

-Compression: $A_{sl,c} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 983.3185$

-Compression: $A_{sl,com} = 983.3185$

-Middle: $A_{sl,mid} = 1325.752$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,jacket} = 829.3805$

-Compression: $A_{sl,com,jacket} = 829.3805$

-Middle: $A_{sl,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,core} = 153.938$

-Compression: $A_{sl,com,core} = 153.938$

-Middle: $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 17.50$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.0122049$

$u = y + p = 0.0122049$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.00770934$ ((4.29), Biskinis Phd)

$M_y = 1.0142E+008$

$L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 300.00

From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.3155E+012$

factor = 0.36543691

$A_g = 40000.00$

Mean concrete strength: $f'_c = (f'_{c,jacket} * Area_{jacket} + f'_{c,core} * Area_{core}) / Area_{section} = 33.00$

$N = 218376.72$

$E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

```

y = Min( y_ten, y_com)
y_ten = 3.1090581E-005
with fy = 555.56
d = 172.00
y = 0.48055007
A = 0.10713558
B = 0.06707136
with pt = 0.02858484
pc = 0.02858484
pv = 0.03853931
N = 218376.72
b = 200.00
" = 0.1627907
y_comp = 2.6245742E-005
with fc = 33.00
Ec = 26999.444
y = 0.48735376
A = 0.08128164
B = 0.05564476
with Es = 200000.00

```

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.00449557$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

shear control ratio $V_y E / V_{CoI} E = 0.4563967$

$d = d_{external} = 172.00$

$s = s_{external} = 150.00$

$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_{fe} / f_s) = 0.00885929$

jacket: $s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00785398$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h_1 = 200.00$

$s_1 = 100.00$

core: $s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00100531$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h_2 = 100.00$

$s_2 = 250.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$N_{UD} = 218376.72$

$A_g = 40000.00$

$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 33.00$

$f_{yIE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein =$

555.56

$f_{yIE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$

$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.09570899$

$b = 200.00$

$d = 172.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)

Calculation No. 9

column C1, Floor 1

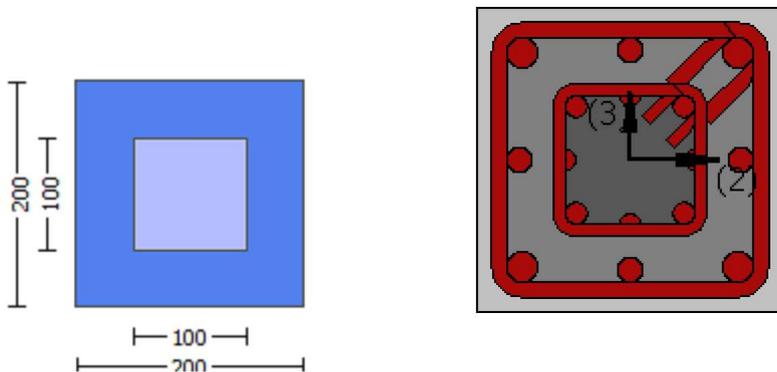
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

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, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3301E+008$

Shear Force, $V_a = -37594.437$

EDGE -B-

Bending Moment, $M_b = -7.4968E+006$

Shear Force, $V_b = 37594.437$

BOTH EDGES

Axial Force, $F = -218084.658$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 2001.195$

-Compression: $A_{sc} = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 983.3185$

-Compression: $A_{sc,com} = 983.3185$

-Middle: $A_{st,mid} = 1325.752$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 141958.469$

V_n (10.3), ASCE 41-17) = $kn1 \cdot V_{ColO} = 141958.469$

$V_{Col} = 141958.469$

$kn1 = 1.00$

displacement_ductility_demand = 0.46397517

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 4.00$

$M_u = 1.3301E+008$

$V_u = 37594.437$

$d = 0.8 \cdot h = 160.00$

$N_u = 218084.658$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$$s/d = 0.625$$

Vs2 = 0.00 is calculated for core, with:

$$d = 80.00$$

$$A_v = 100530.965$$

$$f_y = 500.00$$

$$s = 250.00$$

Vs2 is multiplied by Col2 = 0.00

$$s/d = 3.125$$

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 106288.613

$$b_w = 200.00$$

displacement_ductility_demand is calculated as ϕ / y

- Calculation of ϕ / y for END A -
for rotation axis 3 and integ. section (a)

From analysis, chord rotation = 0.04221101

$$y = (M_y * L_s / 3) / E_{eff} = 0.09097686 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.0143E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3537.917$$

From table 10.5, ASCE 41_17: $E_{eff} = \text{factor} * E_c * I_g = 1.3147E+012$

$$\text{factor} = 0.36521565$$

$$A_g = 40000.00$$

$$\text{Mean concrete strength: } f'_c = (f'_{c_jacket} * A_{jacket} + f'_{c_core} * A_{core}) / A_{section} = 33.00$$

$$N = 218084.658$$

$$E_c * I_g = E_{c_jacket} * I_{g_jacket} + E_{c_core} * I_{g_core} = 3.5999E+012$$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$$y = \text{Min}(y_{ten}, y_{com})$$

$$y_{ten} = 3.1087819E-005$$

with $f_y = 555.56$

$$d = 172.00$$

$$y = 0.48050392$$

$$A = 0.1071203$$

$$B = 0.06705607$$

with $p_t = 0.02858484$

$$p_c = 0.02858484$$

$$p_v = 0.03853931$$

$$N = 218084.658$$

$$b = 200.00$$

$$" = 0.1627907$$

$$y_{comp} = 2.6249185E-005$$

with $f_c = 33.00$

$$E_c = 26999.444$$

$$y = 0.48728983$$

$$A = 0.08130094$$

$$B = 0.05564476$$

with $E_s = 200000.00$

Calculation of ratio l_b / l_d

Adequate Lap Length: $l_b / l_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Calculation No. 10

column C1, Floor 1

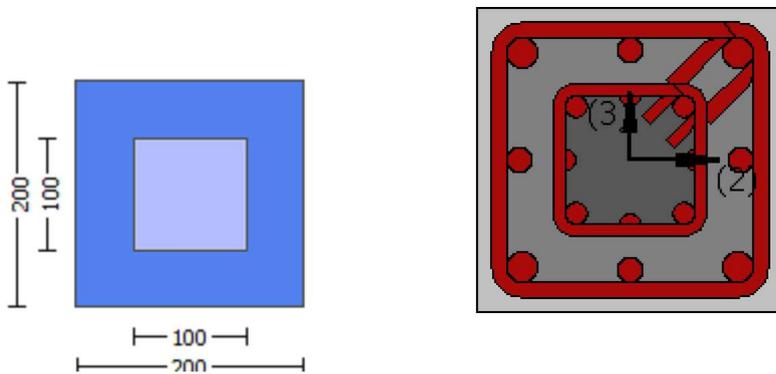
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (μ)

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, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height, $H = 200.00$

External Width, $W = 200.00$
Internal Height, $H = 100.00$
Internal Width, $W = 100.00$
Cover Thickness, $c = 10.00$
Mean Confinement Factor overall section = 1.06329
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou, \min} >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, $V_a = -8.1187678E-030$
EDGE -B-
Shear Force, $V_b = 8.1187678E-030$
BOTH EDGES
Axial Force, $F = -219397.073$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $A_{st} = 0.00$
-Compression: $A_{sc} = 3292.389$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $A_{st, \text{ten}} = 983.3185$
-Compression: $A_{sc, \text{com}} = 983.3185$
-Middle: $A_{sc, \text{mid}} = 1325.752$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.4563967$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3727E+008$
 $M_{u1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $M_{u1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3727E+008$
 $M_{u2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
 $M_{u2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 3.2469244E-005$
 $M_u = 1.3727E+008$

with full section properties:

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 ω (5A.5, TBDY) = 0.002

Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01053874$
 we (5.4c) = 0.03096488
 ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
 $ase1 = 0.16608997$
 $bo_1 = 170.00$
 $ho_1 = 170.00$
 $bi2_1 = 115600.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh_{min} * Fy_{we} = \text{Min}(psh_x * Fy_{we}, psh_y * Fy_{we}) = 6.15233$

 $psh_x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 6.15233$
 $ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

 $psh_y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 6.15233$
 $ps1$ (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2$ (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

 $A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $cc = 0.00263293$
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00

$lo/lou_{min} = lb/ld = 1.00$

$su1 = 0.4 * esu1_{nominal}$ ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: $esu1_{nominal} = 0.08$,

For calculation of $esu1_{nominal}$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1 / 1.2$, from table 5.1, TBDY.

$y1, sh1, ft1, fy1$, are also multiplied by $\text{Min}(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs1 = (fs_{jacket} * A_{sl,ten,jacket} + fs_{core} * A_{sl,ten,core}) / A_{sl,ten} = 694.45$

with $Es1 = (Es_{jacket} * A_{sl,ten,jacket} + Es_{core} * A_{sl,ten,core}) / A_{sl,ten} = 200000.00$

$y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * A_{sl,com,jacket} + fs_{core} * A_{sl,com,core}) / A_{sl,com} = 694.45$
 with $Es_2 = (Es_{jacket} * A_{sl,com,jacket} + Es_{core} * A_{sl,com,core}) / A_{sl,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $suv = 0.4 * esuv_{nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * A_{sl,mid,jacket} + fs_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 694.45$
 with $Es_v = (Es_{jacket} * A_{sl,mid,jacket} + Es_{mid} * A_{sl,mid,core}) / A_{sl,mid} = 200000.00$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{sl,ten} / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = A_{sl,com} / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = A_{sl,mid} / (b * d) * (fsv / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 ---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
 ---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
 ---->
 Case/Assumption Rejected.
 ---->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 ---->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
 ---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 ---->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 ---->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: $bo, do, d'o$
 - $N, 1, 2, v$ normalised to $bo * do$, instead of $b * d$
 - f_c, c_c 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 satisfied

--->

*cu (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

--->

u = cu (4.2) = 3.2469244E-005

Mu = M_{Ro}

Calculation of ratio lb/l_d

Adequate Lap Length: lb/l_d >= 1

Calculation of Mu1-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

f_c = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*A_{ext}+ase2*A_{int})/A_{sec} = 0.16608997

ase1 = 0.16608997

bo_1 = 170.00

ho_1 = 170.00

bi2_1 = 115600.00

ase2 = Max(ase1,ase2) = 0.16608997

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*F_{ywe} = Min(psh,x*F_{ywe} , psh,y*F_{ywe}) = 6.15233

psh_x*F_{ywe} = psh1*F_{ywe1}+ps2*F_{ywe2} = 6.15233

ps1 (external) = (A_{sh1}*h1/s1)/A_{sec} = 0.00785398

A_{sh1} = A_{stir_1}*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 200.00

ps2 (internal) = (A_{sh2}*h2/s2)/A_{sec} = 0.00100531

A_{sh2} = A_{stir_2}*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

psh_y*F_{ywe} = psh1*F_{ywe1}+ps2*F_{ywe2} = 6.15233

ps1 (external) = (A_{sh1}*h1/s1)/A_{sec} = 0.00785398

A_{sh1} = A_{stir_1}*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 200.00

$$ps_2 \text{ (internal)} = (A_{sh2} \cdot h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} \cdot n_{s_2} = 100.531$$

$$No \text{ stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \text{min} = lb/ld = 1.00$$

$$su_1 = 0.4 \cdot esu_{1_nominal} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1_nominal} = 0.08,$$

For calculation of $esu_{1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
characteristic value $fsy_1 = fs_1/1.2$, from table 5.1, TBDY.

$$y_1, sh_1, ft_1, fy_1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_1 = (fs_{jacket} \cdot A_{sl, \text{ten}, jacket} + fs_{core} \cdot A_{sl, \text{ten}, core}) / A_{sl, \text{ten}} = 694.45$$

$$\text{with } Es_1 = (Es_{jacket} \cdot A_{sl, \text{ten}, jacket} + Es_{core} \cdot A_{sl, \text{ten}, core}) / A_{sl, \text{ten}} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$su_2 = 0.032$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 1.00$$

$$su_2 = 0.4 \cdot esu_{2_nominal} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{2_nominal} = 0.08,$$

For calculation of $esu_{2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fsy_2 = fs_2/1.2$, from table 5.1, TBDY.

$$y_2, sh_2, ft_2, fy_2, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs_2 = (fs_{jacket} \cdot A_{sl, \text{com}, jacket} + fs_{core} \cdot A_{sl, \text{com}, core}) / A_{sl, \text{com}} = 694.45$$

$$\text{with } Es_2 = (Es_{jacket} \cdot A_{sl, \text{com}, jacket} + Es_{core} \cdot A_{sl, \text{com}, core}) / A_{sl, \text{com}} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$suv = 0.032$$

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

$$lo/lou, \text{min} = lb/ld = 1.00$$

$$suv = 0.4 \cdot esuv_{nominal} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{nominal} = 0.08,$$

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$$y_v, sh_v, ft_v, fy_v, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{jacket} \cdot A_{sl, \text{mid}, jacket} + fs_{mid} \cdot A_{sl, \text{mid}, core}) / A_{sl, \text{mid}} = 694.45$$

$$\text{with } Es_v = (Es_{jacket} \cdot A_{sl, \text{mid}, jacket} + Es_{mid} \cdot A_{sl, \text{mid}, core}) / A_{sl, \text{mid}} = 200000.00$$

$$1 = A_{sl, \text{ten}} / (b \cdot d) \cdot (fs_1 / fc) = 0.60153764$$

$$2 = A_{sl, \text{com}} / (b \cdot d) \cdot (fs_2 / fc) = 0.60153764$$

$$v = A_{sl, \text{mid}} / (b \cdot d) \cdot (fsv / fc) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

```

d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
  c = confinement factor = 1.06329
  1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
  2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
  v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
  cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
  *cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
  u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

Calculation of ratio lb/d
-----
Adequate Lap Length: lb/d >= 1
-----
-----
Calculation of Mu2+
-----
-----

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
  u = 3.2469244E-005
  Mu = 1.3727E+008
-----

with full section properties:

```

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 $c_o (5A.5, TBDY) = 0.002$
 Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.01053874$
 $w_e (5.4c) = 0.03096488$
 $a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$
 $a_{se1} = 0.16608997$
 $b_{o_1} = 170.00$
 $h_{o_1} = 170.00$
 $b_{i2_1} = 115600.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$
 $b_{o_2} = 92.00$
 $h_{o_2} = 92.00$
 $b_{i2_2} = 33856.00$
 $p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$

$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$
 $p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$
 $p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$
 $A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$
 No stirrups, $n_{s_1} = 2.00$
 $h_1 = 200.00$
 $p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$
 $A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$
 No stirrups, $n_{s_2} = 2.00$
 $h_2 = 100.00$

$A_{sec} = 40000.00$
 $s_1 = 100.00$
 $s_2 = 250.00$
 $f_{ywe1} = 694.45$
 $f_{ywe2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A5), TBDY), TBDY: $c_c = 0.00263293$
 $c = \text{confinement factor} = 1.06329$

$y_1 = 0.0025$
 $sh_1 = 0.008$
 $ft_1 = 833.34$
 $fy_1 = 694.45$
 $su_1 = 0.032$

using (30) in Bisikinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$l_o / l_{ou, \min} = l_b / d = 1.00$

$su_1 = 0.4 * e_{su1_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{su1_nominal} = 0.08$,

For calculation of $e_{su1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered
 characteristic value $f_{sy1} = f_{s1} / 1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b / d)^{2/3})$, 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 $E_{s1} = (E_{s, \text{jacket}} * A_{s, \text{ten, jacket}} + E_{s, \text{core}} * A_{s, \text{ten, core}}) / A_{s, \text{ten}} = 200000.00$

$y_2 = 0.0025$

$sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
 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
 $lo/lo_{min} = lb/lb_{min} = 1.00$
 $su_2 = 0.4 * esu_{2,nominal} ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
 For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
 characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs_2 = (fs_{jacket} * Asl_{com,jacket} + fs_{core} * Asl_{com,core}) / Asl_{com} = 694.45$
 with $Es_2 = (Es_{jacket} * Asl_{com,jacket} + Es_{core} * Asl_{com,core}) / Asl_{com} = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 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.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_{jacket} * Asl_{mid,jacket} + fs_{mid} * Asl_{mid,core}) / Asl_{mid} = 694.45$
 with $Es_v = (Es_{jacket} * Asl_{mid,jacket} + Es_{mid} * Asl_{mid,core}) / Asl_{mid} = 200000.00$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.60153764$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.60153764$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = Asl_{ten} / (b * d) * (fs_1 / fc) = 0.77530517$
 $2 = Asl_{com} / (b * d) * (fs_2 / fc) = 0.77530517$
 $v = Asl_{mid} / (b * d) * (fsv / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < v_{s,y_2}$ - LHS eq.(4.5) is not satisfied
 --->
 $v < v_{s,c}$ - RHS eq.(4.5) is 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
 --->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o

- N, 1, 2, v normalised to $b_0 \cdot d_0$, instead of $b \cdot d$
- parameters of confined concrete, f_{cc} , c_c , 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 satisfied

* c_u (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

u = c_u (4.2) = 3.2469244E-005

Mu = M_{Ro}

 Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

 Calculation of Mu₂-

 Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

 with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

f_c = 33.00

c_o (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01053874$

w_e (5.4c) = 0.03096488

a_{se} ((5.4d), TBDY) = $(a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$

a_{se1} = 0.16608997

b_{o_1} = 170.00

h_{o_1} = 170.00

b_{i_1} = 115600.00

a_{se2} = Max(a_{se1}, a_{se2}) = 0.16608997

b_{o_2} = 92.00

h_{o_2} = 92.00

b_{i_2} = 33856.00

psh_{min}*F_{ywe} = Min(psh_x*F_{ywe}, psh_y*F_{ywe}) = 6.15233

 psh_x*F_{ywe} = psh₁*F_{ywe1} + psh₂*F_{ywe2} = 6.15233

ps₁ (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

A_{sh1} = Astir₁*n_{s_1} = 157.0796

No stirups, n_{s_1} = 2.00

h₁ = 200.00

ps₂ (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

A_{sh2} = Astir₂*n_{s_2} = 100.531

No stirups, n_{s_2} = 2.00

$$h2 = 100.00$$

$$\begin{aligned} psh_y * Fywe &= psh1 * Fywe1 + ps2 * Fywe2 = 6.15233 \\ ps1 \text{ (external)} &= (Ash1 * h1 / s1) / Asec = 0.00785398 \\ Ash1 &= Astir_1 * ns_1 = 157.0796 \\ \text{No stirups, } ns_1 &= 2.00 \\ h1 &= 200.00 \\ ps2 \text{ (internal)} &= (Ash2 * h2 / s2) / Asec = 0.00100531 \\ Ash2 &= Astir_2 * ns_2 = 100.531 \\ \text{No stirups, } ns_2 &= 2.00 \\ h2 &= 100.00 \end{aligned}$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \text{min} = lb/l_d = 1.00$$

$$su1 = 0.4 * esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1, ft1, fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1, ft1, fy1, are also multiplied by $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, 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

$$lo/lou, \text{min} = lb/l_b, \text{min} = 1.00$$

$$su2 = 0.4 * esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

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 $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, 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

$$lo/lou, \text{min} = lb/l_d = 1.00$$

$$suv = 0.4 * esuv_nominal \text{ ((5.5), TBDY)} = 0.032$$

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 $\text{Min}(1, 1.25 * (lb/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$
 with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.60153764$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.60153764$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.8110188$

and confined core properties:

$b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.77530517$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.77530517$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

Case/Assumption Rejected.

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

$v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

$\alpha_{cu} (4.10) = 0.45915168$

$M_{Rc} (4.17) = 1.5179E+008$

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- $N, 1, 2, v$ normalised to $b_o \cdot d_o$, instead of $b \cdot d$
- f_{cc}, cc parameters of confined concrete, f_{cc}, cc , used in lieu of f_c, α_{cu}

Subcase: Rupture of tension steel

$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

Subcase rejected

New Subcase: Failure of compression zone

$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied

$\alpha_{cu} (4.12) = 0.51649622$

$M_{Ro} (4.16) = 1.3727E+008$

$u = \alpha_{cu} (4.2) = 3.2469244E-005$

$\mu = M_{Ro}$

 Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

 Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$

$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$

$V_{ColO} = 200506.935$

$kn1 = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$bw = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 200506.935$

$V_{r2} = V_{Col} ((10.3), ASCE 41-17) = knl * V_{ColO}$

$V_{ColO} = 200506.935$

$kn1 = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

Av = 100530.965
fy = 555.56
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45

External Height, H = 200.00
External Width, W = 200.00
Internal Height, H = 100.00
Internal Width, W = 100.00
Cover Thickness, c = 10.00
Mean Confinement Factor overall section = 1.06329
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length (lo/lou,min>=1)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -1.9686856E-030
EDGE -B-
Shear Force, Vb = 1.9686856E-030

BOTH EDGES

Axial Force, $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{,ten} = 983.3185$

-Compression: $As_{,com} = 983.3185$

-Middle: $As_{,mid} = 1325.752$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.4563967$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$

$Mu_{1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$

$Mu_{2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

ϕ_c (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01053874$

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = $(ase_1 * A_{ext} + ase_2 * A_{int}) / A_{sec} = 0.16608997$

$ase_1 = 0.16608997$

$bo_1 = 170.00$

$ho_1 = 170.00$

$bi_{2,1} = 115600.00$

$ase_2 = \text{Max}(ase_1, ase_2) = 0.16608997$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi_{2,2} = 33856.00$

$psh_{,min} * F_{ywe} = \text{Min}(psh_{,x} * F_{ywe}, psh_{,y} * F_{ywe}) = 6.15233$

$psh_{,x} * F_{ywe} = psh_1 * F_{ywe1} + ps_2 * F_{ywe2} = 6.15233$

ps_1 (external) = $(A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$

$A_{sh1} = Astir_1 * ns_1 = 157.0796$

No stirups, $ns_1 = 2.00$

$h_1 = 200.00$

ps_2 (internal) = $(A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$

$A_{sh2} = Astir_2 * ns_2 = 100.531$

No stirups, ns₂ = 2.00
h₂ = 100.00

psh_y*Fywe = psh₁*Fywe₁+ps₂*Fywe₂ = 6.15233
ps₁ (external) = (Ash₁*h₁/s₁)/Asec = 0.00785398
Ash₁ = Astir₁*ns₁ = 157.0796
No stirups, ns₁ = 2.00
h₁ = 200.00
ps₂ (internal) = (Ash₂*h₂/s₂)/Asec = 0.00100531
Ash₂ = Astir₂*ns₂ = 100.531
No stirups, ns₂ = 2.00
h₂ = 100.00

Asec = 40000.00

s₁ = 100.00

s₂ = 250.00

fywe₁ = 694.45

fywe₂ = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y₁ = 0.0025

sh₁ = 0.008

ft₁ = 833.34

fy₁ = 694.45

su₁ = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/l_d = 1.00

su₁ = 0.4*esu_{1_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{1_nominal} = 0.08,

For calculation of esu_{1_nominal} and y₁, sh₁,ft₁,fy₁, it is considered
characteristic value fsy₁ = fs₁/1.2, from table 5.1, TBDY.

y₁, sh₁,ft₁,fy₁, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₁ = (fs_{jacket}*Asl_{ten,jacket} + fs_{core}*Asl_{ten,core})/Asl_{ten} = 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/l_{b,min} = 1.00

su₂ = 0.4*esu_{2_nominal} ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu_{2_nominal} = 0.08,

For calculation of esu_{2_nominal} and y₂, sh₂,ft₂,fy₂, it is considered
characteristic value fsy₂ = fs₂/1.2, from table 5.1, TBDY.

y₂, sh₂,ft₂,fy₂, are also multiplied by Min(1,1.25*(lb/l_d)^{2/3}), from 10.3.5, ASCE 41-17.

with fs₂ = (fs_{jacket}*Asl_{com,jacket} + fs_{core}*Asl_{com,core})/Asl_{com} = 694.45

with Es₂ = (Es_{jacket}*Asl_{com,jacket} + Es_{core}*Asl_{com,core})/Asl_{com} = 200000.00

y_v = 0.0025

sh_v = 0.008

ft_v = 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/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 fsy_v = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_{nominal} and y_v, sh_v,ft_v,fy_v, it is considered
characteristic value fsy_v = fsv/1.2, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{sv} = (f_{sjacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$

with $E_{sv} = (E_{sjacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.60153764$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.60153764$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.77530517$

$2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.77530517$

$v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

Case/Assumption Rejected.

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

$v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

$\alpha_{cu} (4.10) = 0.45915168$

$M_{Rc} (4.17) = 1.5179E+008$

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o

- $N, 1, 2, v$ normalised to $b_o \cdot d_o$, instead of $b \cdot d$

- f_{cc}, cc parameters of confined concrete, f_{cc}, cc , used in lieu of f_c, 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 satisfied

$\alpha_{cu} (4.12) = 0.51649622$

$M_{Ro} (4.16) = 1.3727E+008$

$u = \alpha_{cu} (4.2) = 3.2469244E-005$

$\mu = M_{Ro}$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

Calculation of μ_{u1} -

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o(5A.5, \text{TBDY}) = 0.002$$

$$\text{Final value of } \phi_u: \phi_u^* = \text{shear_factor} * \text{Max}(\phi_{cu}, \phi_{cc}) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \phi_{cu} = 0.01053874$$

$$\phi_{we} \text{ (5.4c)} = 0.03096488$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \phi_{cc} = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{ou, \min} = l_b / d = 1.00$$

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu1_nominal = 0.08$,
 For calculation of $esu1_nominal$ and $y1, sh1, ft1, fy1$, it is considered
 characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs1 = (fs_jacket * Asl,ten,jacket + fs_core * Asl,ten,core) / Asl,ten = 694.45$
 with $Es1 = (Es_jacket * Asl,ten,jacket + Es_core * Asl,ten,core) / Asl,ten = 200000.00$
 $y2 = 0.0025$
 $sh2 = 0.008$
 $ft2 = 833.34$
 $fy2 = 694.45$
 $su2 = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/lb,min = 1.00$
 $su2 = 0.4 * esu2_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esu2_nominal = 0.08$,
 For calculation of $esu2_nominal$ and $y2, sh2, ft2, fy2$, it is considered
 characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fs2 = (fs_jacket * Asl,com,jacket + fs_core * Asl,com,core) / Asl,com = 694.45$
 with $Es2 = (Es_jacket * Asl,com,jacket + Es_core * Asl,com,core) / Asl,com = 200000.00$
 $yv = 0.0025$
 $shv = 0.008$
 $ftv = 833.34$
 $fyv = 694.45$
 $suv = 0.032$
 using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 Shear_factor = 1.00
 $lo/lou,min = lb/ld = 1.00$
 $suv = 0.4 * esuv_nominal ((5.5), TBDY) = 0.032$
 From table 5A.1, TBDY: $esuv_nominal = 0.08$,
 considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY
 For calculation of $esuv_nominal$ and yv, shv, ftv, fyv , it is considered
 characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.
 $y1, sh1, ft1, fy1$, are also multiplied by $Min(1, 1.25 * (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.
 with $fsv = (fs_jacket * Asl,mid,jacket + fs_mid * Asl,mid,core) / Asl,mid = 694.45$
 with $Esv = (Es_jacket * Asl,mid,jacket + Es_mid * Asl,mid,core) / Asl,mid = 200000.00$
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.60153764$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.60153764$
 $v = Asl,mid / (b * d) * (fsv / fc) = 0.8110188$
 and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c =$ confinement factor = 1.06329
 $1 = Asl,ten / (b * d) * (fs1 / fc) = 0.77530517$
 $2 = Asl,com / (b * d) * (fs2 / fc) = 0.77530517$
 $v = Asl,mid / (b * d) * (fsv / fc) = 1.0453$
 Case/Assumption: Unconfined full section - Steel rupture
 ' satisfies Eq. (4.3)
 --->
 $v < vs,y2$ - LHS eq.(4.5) is not satisfied
 --->
 $v < vs,c$ - RHS eq.(4.5) is not satisfied
 --->
 Case/Assumption Rejected.
 --->
 New Case/Assumption: Unconfined full section - Spalling of concrete cover
 ' satisfies Eq. (4.4)
 --->
 $v < s,y1$ - LHS eq.(4.7) is not satisfied
 --->

v < v_{c,y1} - RHS eq.(4.6) is satisfied

---->

cu (4.10) = 0.45915168

M_{Rc} (4.17) = 1.5179E+008

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- N, 1, 2, v normalised to b_o*d_o, instead of b*d
- - parameters of confined concrete, f_{cc}, 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 satisfied

---->

*cu (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

---->

u = cu (4.2) = 3.2469244E-005

Mu = M_{Ro}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu₂₊

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

f_c = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*A_{ext}+ase2*A_{int})/A_{sec} = 0.16608997

ase1 = 0.16608997

bo_1 = 170.00

ho_1 = 170.00

bi2_1 = 115600.00

ase2 = Max(ase1,ase2) = 0.16608997

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*F_{ywe} = Min(psh,x*F_{ywe} , psh,y*F_{ywe}) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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 = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo
-----

```

Calculation of ratio 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:

$$\mu = 3.2469244E-005$$

$$\mu_2 = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu_2: \mu_2^* = \text{shear_factor} * \text{Max}(\mu_2, \mu_c) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_2 = 0.01053874$$

$$\mu_{we} \text{ (5.4c)} = 0.03096488$$

$$\text{ase ((5.4d), TBDY)} = (\text{ase}_1 * A_{ext} + \text{ase}_2 * A_{int}) / A_{sec} = 0.16608997$$

$$\text{ase}_1 = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$\text{ase}_2 = \text{Max}(\text{ase}_1, \text{ase}_2) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$\text{psh}_{\min} * F_{ywe} = \text{Min}(\text{psh}_x * F_{ywe}, \text{psh}_y * F_{ywe}) = 6.15233$$

$$\text{psh}_x * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 6.15233$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$\text{psh}_y * F_{ywe} = \text{psh}_1 * F_{ywe1} + \text{ps}_2 * F_{ywe2} = 6.15233$$

$$\text{ps}_1 \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$\text{ps}_2 \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/ld = 1.00$$

$$su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45$$

$$\text{with } Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/lb,min = 1.00$$

$$su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45$$

$$\text{with } Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

$$lo/lou,min = lb/ld = 1.00$$

$$suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45$$

$$\text{with } Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$fcc (5A.2, TBDY) = 35.08866$$

$$cc (5A.5, TBDY) = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517$$

$$2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517$$

$$v = Asl,mid/(b*d)*(fsv/fc) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)

---->

$v < s_1 y_1$ - LHS eq.(4.7) is not satisfied

---->

$v < v_c y_1$ - RHS eq.(4.6) is satisfied

---->

ϕ_{cu} (4.10) = 0.45915168

M_{Rc} (4.17) = 1.5179E+008

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o , d_o , d'_o
- N_1 , N_2 , v normalised to $b_o d_o$, instead of $b d$
- parameters of confined concrete, f_{cc} , ϕ_{cc} , used in lieu of f_c , ϕ_{cu}

---->

Subcase: Rupture of tension steel

---->

$v^* < v^* s_1 y_2$ - 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

---->

$v^* < v^* c_1 y_2$ - LHS eq.(4.6) is satisfied

---->

ϕ_{cu} (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

---->

$u = \phi_{cu}$ (4.2) = 3.2469244E-005

$\mu = M_{Ro}$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$

$V_{r1} = V_{Co1}$ ((10.3), ASCE 41-17) = $k_{nl} V_{Co10}$

$V_{Co10} = 200506.935$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v f_y d/s$ ' is replaced by ' $V_s + f V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $f'_c = (f'_{c_jacket} \text{Area}_{jacket} + f'_{c_core} \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$V_u = 1.9686856E-030$

$d = 0.8 h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.625

Vs2 = 0.00 is calculated for core, with:

d = 80.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 3.125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 122116.319

bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 200506.935

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

VCol0 = 200506.935

knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf' where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00

Mu = 2.0213315E-011

Vu = 1.9686856E-030

d = 0.8*h = 160.00

Nu = 219397.073

Ag = 40000.00

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457

where:

Vs1 = 139627.457 is calculated for jacket, with:

d = 160.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.625

Vs2 = 0.00 is calculated for core, with:

d = 80.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 3.125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 122116.319

bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\phi = 1.00$
 Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
 Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
 Consequently:
 Jacket
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 Existing Column
 New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
 New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
 Concrete Elasticity, $E_c = 26999.444$
 Steel Elasticity, $E_s = 200000.00$
 External Height, $H = 200.00$
 External Width, $W = 200.00$
 Internal Height, $H = 100.00$
 Internal Width, $W = 100.00$
 Cover Thickness, $c = 10.00$
 Element Length, $L = 3000.00$
 Secondary Member
 Smooth Bars
 Ductile Steel
 With Detailing for Earthquake Resistance (including stirrups closed at 135°)
 Longitudinal Bars With Ends Lapped Starting at the End Sections
 Adequate Lap Length ($l_b/l_d > 1$)
 No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -9.9495397E-008$
 Shear Force, $V_2 = -37594.437$
 Shear Force, $V_3 = 6.2539570E-011$
 Axial Force, $F = -218084.658$
 Longitudinal Reinforcement Area Distribution (in 2 divisions)
 -Tension: $As_t = 2001.195$
 -Compression: $As_c = 1291.195$
 Longitudinal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten} = 983.3185$
 -Compression: $As_{c,com} = 983.3185$
 -Middle: $As_{mid} = 1325.752$
 Longitudinal External Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten,jacket} = 829.3805$
 -Compression: $As_{c,com,jacket} = 829.3805$
 -Middle: $As_{mid,jacket} = 402.1239$
 Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)
 -Tension: $As_{t,ten,core} = 153.938$
 -Compression: $As_{c,com,core} = 153.938$
 -Middle: $As_{mid,core} = 923.6282$
 Mean Diameter of Tension Reinforcement, $Db_L = 17.50$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_R = 1.0^*$ $u = 0.07272853$
 $u = y + p = 0.07272853$

- Calculation of y -

$y = (M_y * L_s / 3) / E_{eff} = 0.03857221$ ((4.29), Biskinis Phd)
 $M_y = 1.0143E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.3147E+012$
 factor = 0.36521565

$$A_g = 40000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$$

$$N = 218084.658$$

$$E_c \cdot I_g = E_c_{\text{jacket}} \cdot I_{g_{\text{jacket}}} + E_c_{\text{core}} \cdot I_{g_{\text{core}}} = 3.5999E+012$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 3.1087819E-005$$

$$\text{with } f_y = 555.56$$

$$d = 172.00$$

$$y = 0.48050392$$

$$A = 0.1071203$$

$$B = 0.06705607$$

$$\text{with } p_t = 0.02858484$$

$$p_c = 0.02858484$$

$$p_v = 0.03853931$$

$$N = 218084.658$$

$$b = 200.00$$

$$" = 0.1627907$$

$$y_{\text{comp}} = 2.6249185E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.48728983$$

$$A = 0.08130094$$

$$B = 0.05564476$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.03415631$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $l_b/d \geq 1$

$$\text{shear control ratio } V_y E / V_{CoI} E = 0.4563967$$

$$d = d_{\text{external}} = 172.00$$

$$s = s_{\text{external}} = 150.00$$

$$t = s_1 + s_2 + 2 \cdot t_f / b_w \cdot (f_f e / f_s) = 0.00885929$$

$$\text{jacket: } s_1 = A_{v1} \cdot h_1 / (s_1 \cdot A_g) = 0.00785398$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 200.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} \cdot h_2 / (s_2 \cdot A_g) = 0.00100531$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 100.00$$

$$s_2 = 250.00$$

The term $2 \cdot t_f / b_w \cdot (f_f e / f_s)$ 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 $f_f e / f_s$ normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$$N_{UD} = 218084.658$$

$$A_g = 40000.00$$

$$f_c E = (f_c_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{section}_{\text{area}} = 33.00$$

$$f_y E = (f_y_{\text{ext_Long_Reinf}} \cdot \text{Area}_{\text{ext_Long_Reinf}} + f_y_{\text{int_Long_Reinf}} \cdot \text{Area}_{\text{int_Long_Reinf}}) / \text{Area}_{\text{Tot_Long_Rein}} = 555.56$$

$$f_{yt} E = (f_y_{\text{ext_Trans_Reinf}} \cdot s_1 + f_y_{\text{int_Trans_Reinf}} \cdot s_2) / (s_1 + s_2) = 555.56$$

$$p_l = \text{Area}_{\text{Tot_Long_Rein}} / (b \cdot d) = 0.09570899$$

$$b = 200.00$$

d = 172.00
f_{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

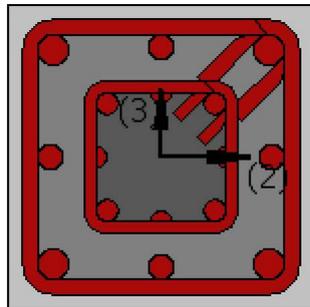
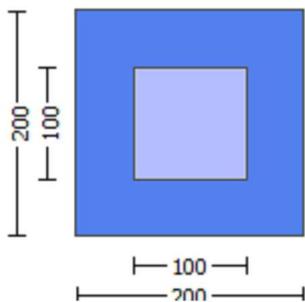
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

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, = 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, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -9.9495397E-008$

Shear Force, $V_a = 6.2539570E-011$

EDGE -B-

Bending Moment, $M_b = -9.0143946E-008$

Shear Force, $V_b = -6.2539570E-011$

BOTH EDGES

Axial Force, $F = -218084.658$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 2001.195$

-Compression: $A_{sc} = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st,ten} = 983.3185$

-Compression: $A_{sl,com} = 983.3185$

-Middle: $A_{sl,mid} = 1325.752$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 177628.325$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 177628.325$

$V_{CoI} = 177628.325$

$k_n = 1.00$

$displacement_ductility_demand = 0.00$

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M / Vd = 2.00$

$M_u = 9.9495397E-008$

$V_u = 6.2539570E-011$

$d = 0.8 \cdot h = 160.00$

$N_u = 218084.658$

$A_g = 40000.00$
 From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$
 where:
 $V_{s1} = 125663.706$ is calculated for jacket, with:
 $d = 160.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.625$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 3.125$
 $V_f ((11-3)-(11.4), ACI 440) = 0.00$
 From (11-11), ACI 440: $V_s + V_f \leq 106288.613$
 $b_w = 200.00$

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 $\theta = 3.1068144E-018$
 $y = (M_y * L_s / 3) / E_{eff} = 0.03857221$ ((4.29), Biskinis Phd))
 $M_y = 1.0143E+008$
 $L_s = M/V$ (with $L_s > 0.1 * L$ and $L_s < 2 * L$) = 1500.00
 From table 10.5, ASCE 41_17: $E_{eff} = factor * E_c * I_g = 1.3147E+012$
 $factor = 0.36521565$
 $A_g = 40000.00$
 Mean concrete strength: $f_c' = (f_c'_{jacket} * Area_{jacket} + f_c'_{core} * Area_{core}) / Area_{section} = 33.00$
 $N = 218084.658$
 $E_c * I_g = E_{c,jacket} * I_{g,jacket} + E_{c,core} * I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of ϕ and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1087819E-005$
 with $f_y = 555.56$
 $d = 172.00$
 $y = 0.48050392$
 $A = 0.1071203$
 $B = 0.06705607$
 with $pt = 0.02858484$
 $pc = 0.02858484$
 $pv = 0.03853931$
 $N = 218084.658$
 $b = 200.00$
 $\rho = 0.1627907$
 $y_{comp} = 2.6249185E-005$
 with $f_c = 33.00$
 $E_c = 26999.444$
 $y = 0.48728983$
 $A = 0.08130094$
 $B = 0.05564476$
 with $E_s = 200000.00$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 12

column C1, Floor 1

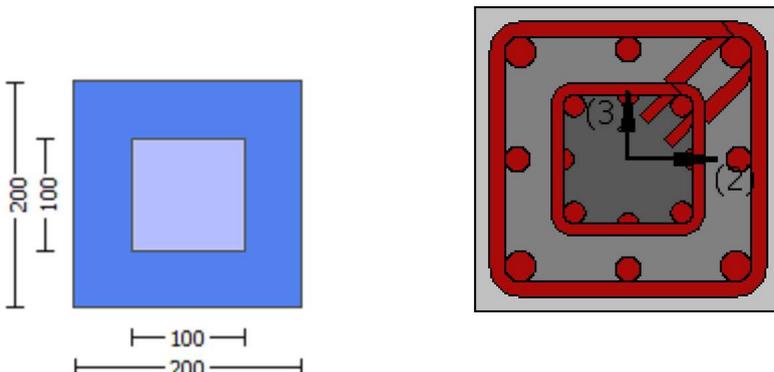
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (θ)

Edge: Start

Local Axis: (3)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Mean Confinement Factor overall section = 1.06329

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou, \min} > 1$)

No FRP Wrapping

Stepwise Properties

At local axis: 3

EDGE -A-

Shear Force, $V_a = -8.1187678E-030$

EDGE -B-

Shear Force, $V_b = 8.1187678E-030$

BOTH EDGES

Axial Force, $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{st, \text{ten}} = 983.3185$

-Compression: $A_{st, \text{com}} = 983.3185$

-Middle: $A_{st, \text{mid}} = 1325.752$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.4563967$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3727E+008$

$M_{u1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$M_{u1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3727E+008$

$M_{u2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$M_{u2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of M_{u1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.2469244E-005$

$M_u = 1.3727E+008$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o (5A.5, TBDY) = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01053874$$

$$w_e (5.4c) = 0.03096488$$

$$a_{se} ((5.4d), TBDY) = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$

$$p_{s1} (\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} (\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor and also multiplied by the shear_factor according to 15.7.1.4, with Shear_factor = 1.00

$$l_o / l_{o, \min} = l_b / d = 1.00$$

$$su_1 = 0.4 * esu_{1, \text{nominal}} ((5.5), TBDY) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu_{1, \text{nominal}} = 0.08,$$

For calculation of $esu_{1, \text{nominal}}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $fsy_1 = fs_1 / 1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b / d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } fs_1 = (fs_{\text{jacket}} * A_{sl, \text{ten, jacket}} + fs_{\text{core}} * A_{sl, \text{ten, core}}) / A_{sl, \text{ten}} = 694.45$$

with $E_{s1} = (E_{s,jacket} \cdot A_{s,ten,jacket} + E_{s,core} \cdot A_{s,ten,core}) / A_{s,ten} = 200000.00$
 $y_2 = 0.0025$
 $sh_2 = 0.008$
 $ft_2 = 833.34$
 $fy_2 = 694.45$
 $su_2 = 0.032$
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
 $l_0/l_{ou,min} = l_b/l_{b,min} = 1.00$
 $su_2 = 0.4 \cdot esu_{2,nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esu_{2,nominal} = 0.08$,
For calculation of $esu_{2,nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered
characteristic value $fs_2 = fs_2/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_2 = (fs_{jacket} \cdot A_{s,com,jacket} + fs_{core} \cdot A_{s,com,core}) / A_{s,com} = 694.45$
with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core}) / A_{s,com} = 200000.00$
 $y_v = 0.0025$
 $sh_v = 0.008$
 $ft_v = 833.34$
 $fy_v = 694.45$
 $su_v = 0.032$
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
 $l_0/l_{ou,min} = l_b/l_d = 1.00$
 $su_v = 0.4 \cdot esuv_{nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $esuv_{nominal} = 0.08$,
considering characteristic value $fs_v = fs_v/1.2$, from table 5.1, TBDY
For calculation of $esuv_{nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered
characteristic value $fs_v = fs_v/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $fs_v = (fs_{jacket} \cdot A_{s,mid,jacket} + fs_{mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$
with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.60153764$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.60153764$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.8110188$
and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $fcc (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.77530517$
 $2 = A_{s,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.77530517$
 $v = A_{s,mid} / (b \cdot d) \cdot (fs_v / fc) = 1.0453$
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
--->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
--->
 $cu (4.10) = 0.45915168$
 $MRC (4.17) = 1.5179E+008$
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

---->
Subcase: Rupture of tension steel

---->
 $v^* < v^*s_y2$ - LHS eq.(4.5) is not satisfied

---->
 $v^* < v^*s_c$ - LHS eq.(4.5) is not satisfied

---->
Subcase rejected

---->
New Subcase: Failure of compression zone

---->
 $v^* < v^*c_y2$ - LHS eq.(4.6) is satisfied

---->
 $*c_u$ (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

---->
u = c_u (4.2) = 3.2469244E-005

Mu = M_{Ro}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu1-

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, cc) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $c_u = 0.01053874$

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$

ase1 = 0.16608997

bo_1 = 170.00

ho_1 = 170.00

bi2_1 = 115600.00

ase2 = Max(ase1, ase2) = 0.16608997

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe, psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1 + ps2*Fywe2 = 6.15233

ps1 (external) = $(A_{sh1} * h1 / s1) / A_{sec} = 0.00785398$

Ash1 = Astir_1 * ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 200.00

ps2 (internal) = $(A_{sh2} * h2 / s2) / A_{sec} = 0.00100531$

Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025

sh2 = 0.008

ft2 = 833.34

fy2 = 694.45

su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025

shv = 0.008

ftv = 833.34

fyv = 694.45

suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered

characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $f_{sv} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 694.45$
with $E_{sv} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.60153764$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.60153764$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 0.8110188$

and confined core properties:

$b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s,ten} / (b \cdot d) \cdot (f_{s1} / f_c) = 0.77530517$
 $2 = A_{s,com} / (b \cdot d) \cdot (f_{s2} / f_c) = 0.77530517$
 $v = A_{s,mid} / (b \cdot d) \cdot (f_{sv} / f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
---->

Case/Assumption Rejected.

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)

---->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
---->

$\text{cu} (4.10) = 0.45915168$
 $\text{MRc} (4.17) = 1.5179\text{E}+008$

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- $N, 1, 2, v$ normalised to $b_o \cdot d_o$, instead of $b \cdot d$
- - parameters of confined concrete, f_{cc}, cc , used in lieu of f_c, 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 satisfied
---->

$*\text{cu} (4.12) = 0.51649622$
 $\text{MRo} (4.16) = 1.3727\text{E}+008$

---->
 $u = \text{cu} (4.2) = 3.2469244\text{E}-005$
 $\text{Mu} = \text{MRo}$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu2+

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01053874$$

$$w_e \text{ (5.4c)} = 0.03096488$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirrups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirrups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$s_u1 = 0.4 * e_{s1_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s1_nominal} = 0.08$,

For calculation of $e_{s1_nominal}$ and y_1, sh_1, ft_1, fy_1 , it is considered characteristic value $f_{sy1} = f_{s1}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s1} = (f_{s,jacket} * A_{s,ten,jacket} + f_{s,core} * A_{s,ten,core}) / A_{s,ten} = 694.45$$

$$\text{with } E_{s1} = (E_{s,jacket} * A_{s,ten,jacket} + E_{s,core} * A_{s,ten,core}) / A_{s,ten} = 200000.00$$

$$y_2 = 0.0025$$

$$sh_2 = 0.008$$

$$ft_2 = 833.34$$

$$fy_2 = 694.45$$

$$s_u2 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_{b,min} = 1.00$$

$$s_u2 = 0.4 * e_{s2_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{s2_nominal} = 0.08$,

For calculation of $e_{s2_nominal}$ and y_2, sh_2, ft_2, fy_2 , it is considered characteristic value $f_{sy2} = f_{s2}/1.2$, from table 5.1, TBDY.

y_2, sh_2, ft_2, fy_2 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{s2} = (f_{s,jacket} * A_{s,com,jacket} + f_{s,core} * A_{s,com,core}) / A_{s,com} = 694.45$$

$$\text{with } E_{s2} = (E_{s,jacket} * A_{s,com,jacket} + E_{s,core} * A_{s,com,core}) / A_{s,com} = 200000.00$$

$$y_v = 0.0025$$

$$sh_v = 0.008$$

$$ft_v = 833.34$$

$$fy_v = 694.45$$

$$s_{uv} = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$$l_o/l_{o,min} = l_b/l_d = 1.00$$

$$s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$$

From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,

considering characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY

For calculation of $e_{suv_nominal}$ and y_v, sh_v, ft_v, fy_v , it is considered characteristic value $f_{syv} = f_{sv}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, fy_1 , are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

$$\text{with } f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$$

$$\text{with } E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.60153764$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.60153764$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 35.08866$$

$$c_c (5A.5, TBDY) = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.77530517$$

$$2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.77530517$$

$$v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

```

---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->
u = cu (4.2) = 3.2469244E-005
Mu = MRo

```

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997

ase1 = 0.16608997

bo_1 = 170.00

ho_1 = 170.00

bi2_1 = 115600.00

ase2 = Max(ase1,ase2) = 0.16608997

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 * (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $e_{suv_nominal}$ and γ_v , sh_v, ft_v, fy_v , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $\gamma_1, sh_1, ft_1, fy_1$, 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 $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.60153764$
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.60153764$
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.8110188$
and confined core properties:
 $b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.77530517$
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.77530517$
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 1.0453$
Case/Assumption: Unconfined full section - Steel rupture
'satisfies Eq. (4.3)
--->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied
--->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
'satisfies Eq. (4.4)
--->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied
--->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
--->
 $cu (4.10) = 0.45915168$
 $M_{Rc} (4.17) = 1.5179E+008$
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- $N, 1, 2, v$ normalised to $b_o * d_o$, instead of $b * d$
- f_{cc}, cc 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 satisfied
--->
 $*cu (4.12) = 0.51649622$
 $M_{Ro} (4.16) = 1.3727E+008$
--->
 $u = cu (4.2) = 3.2469244E-005$
 $M_u = M_{Ro}$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$

$V_{r1} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 200506.935$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 3.125$

$V_f \text{ ((11-3)-(11.4), ACI 440)} = 0.00$

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 200506.935$

$V_{r2} = V_{Col} \text{ ((10.3), ASCE 41-17)} = k_{nl} * V_{Col0}$

$V_{Col0} = 200506.935$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ ' where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} * \text{Area}_{jacket} + f_c'_{core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

Vs1 = 139627.457 is calculated for jacket, with:

d = 160.00

Av = 157079.633

fy = 555.56

s = 100.00

Vs1 is multiplied by Col1 = 1.00

s/d = 0.625

Vs2 = 0.00 is calculated for core, with:

d = 80.00

Av = 100530.965

fy = 555.56

s = 250.00

Vs2 is multiplied by Col2 = 0.00

s/d = 3.125

Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 122116.319

bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

Existing Column

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, fs = 1.25*fsm = 694.45

Existing Column

New material: Steel Strength, fs = 1.25*fsm = 694.45

#####

External Height, H = 200.00

External Width, W = 200.00

Internal Height, H = 100.00

Internal Width, W = 100.00

Cover Thickness, c = 10.00

Mean Confinement Factor overall section = 1.06329

Element Length, L = 3000.00

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length (lo/ou,min>=1)

No FRP Wrapping

Stepwise Properties

At local axis: 2

EDGE -A-

Shear Force, $V_a = -1.9686856E-030$

EDGE -B-

Shear Force, $V_b = 1.9686856E-030$

BOTH EDGES

Axial Force, $F = -219397.073$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $As_t = 0.00$

-Compression: $As_c = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $As_{t,ten} = 983.3185$

-Compression: $As_{l,com} = 983.3185$

-Middle: $As_{l,mid} = 1325.752$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.4563967$

Member Controlled by Flexure ($V_e/V_r < 1$)

Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$

with

$M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$

$Mu_{1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination

$Mu_{1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination

$M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$

$Mu_{2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination

$Mu_{2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$\phi_u = 3.2469244E-005$

$Mu = 1.3727E+008$

with full section properties:

$b = 200.00$

$d = 172.00$

$d' = 28.00$

$v = 0.19326733$

$N = 219397.073$

$f_c = 33.00$

α (5A.5, TBDY) = 0.002

Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: $\phi_u = 0.01053874$

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$

$ase1 = 0.16608997$

$bo_1 = 170.00$

$ho_1 = 170.00$

$bi2_1 = 115600.00$

$ase2 = \text{Max}(ase1, ase2) = 0.16608997$

$bo_2 = 92.00$

$ho_2 = 92.00$

$bi2_2 = 33856.00$

$$psh,min*Fywe = \text{Min}(psh,x*Fywe , psh,y*Fywe) = 6.15233$$

$$psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233$$

$$ps1 \text{ (external)} = (Ash1*h1/s1)/Asec = 0.00785398$$

$$Ash1 = Astir_1*ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2*h2/s2)/Asec = 0.00100531$$

$$Ash2 = Astir_2*ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A.5), \text{ TBDY}), \text{ TBDY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou,min = lb/l_d = 1.00$$

$$su1 = 0.4*esu1_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_nominal = 0.08,$$

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25*(lb/l_d)^{2/3})$, 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

$$lo/lou,min = lb/l_b,min = 1.00$$

$$su2 = 0.4*esu2_nominal \text{ ((5.5), TBDY)} = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_nominal = 0.08,$$

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, 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
 $l_o/l_{o,min} = l_b/l_d = 1.00$
 $s_{uv} = 0.4 * e_{suv_nominal} ((5.5), TBDY) = 0.032$
From table 5A.1, TBDY: $e_{suv_nominal} = 0.08$,
considering characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY
For calculation of $e_{suv_nominal}$ and γ_v , sh_v, f_{tv}, f_{yv} , it is considered
characteristic value $f_{sv} = f_{sv}/1.2$, from table 5.1, TBDY.
 $\gamma_1, sh_1, f_{t1}, f_{y1}$, are also multiplied by $\text{Min}(1, 1.25 * (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.
with $f_{sv} = (f_{s,jacket} * A_{s,mid,jacket} + f_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 694.45$
with $E_{sv} = (E_{s,jacket} * A_{s,mid,jacket} + E_{s,mid} * A_{s,mid,core}) / A_{s,mid} = 200000.00$
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.60153764$
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.60153764$
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 0.8110188$

and confined core properties:

$b = 170.00$
 $d = 157.00$
 $d' = 13.00$
 $f_{cc} (5A.2, TBDY) = 35.08866$
 $cc (5A.5, TBDY) = 0.00263293$
 $c = \text{confinement factor} = 1.06329$
 $1 = A_{s,ten} / (b * d) * (f_{s1} / f_c) = 0.77530517$
 $2 = A_{s,com} / (b * d) * (f_{s2} / f_c) = 0.77530517$
 $v = A_{s,mid} / (b * d) * (f_{sv} / f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

---->
Case/Assumption Rejected.

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->
 $v < s_{y1}$ - LHS eq.(4.7) is not satisfied

---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->
 $c_u (4.10) = 0.45915168$
 $M_{Rc} (4.17) = 1.5179E+008$

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- $N, 1, 2, v$ normalised to $b_o * d_o$, instead of $b * d$
- parameters of confined concrete, f_{cc}, 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 satisfied

---->
 $*c_u (4.12) = 0.51649622$
 $M_{Ro} (4.16) = 1.3727E+008$

---->
 $u = c_u (4.2) = 3.2469244E-005$
 $M_u = M_{Ro}$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_1

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$\mu = 3.2469244E-005$$

$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } \mu: \mu^* = \text{shear_factor} * \text{Max}(\mu_c, \mu_{cc}) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } \mu_c = 0.01053874$$

$$\mu_{cc} \text{ (5.4c)} = 0.03096488$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{s1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{s2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A5), TBDY), TBDY: } \mu_{cc} = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb = 1.00

suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esuv_nominal = 0.08,

considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY

For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/lb)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764

2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764

v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00

d = 157.00

d' = 13.00

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < v_{s,c} - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

v < s_{y1} - LHS eq.(4.7) is not satisfied

--->

v < v_{c,y1} - RHS eq.(4.6) is satisfied

--->

cu (4.10) = 0.45915168

M_{Rc} (4.17) = 1.5179E+008

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
- N₁, N₂, 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 satisfied

--->

*cu (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

--->

u = cu (4.2) = 3.2469244E-005

Mu = M_{Ro}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

f_c = 33.00

c_o (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

w_e (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997

ase1 = 0.16608997

bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

```

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
--->
v < vs,y2 - LHS eq.(4.5) is not satisfied
--->
v < vs,c - RHS eq.(4.5) is not satisfied
--->
Case/Assumption Rejected.
--->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
--->
v < sy1 - LHS eq.(4.7) is not satisfied
--->
v < vc,y1 - RHS eq.(4.6) is satisfied
--->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
--->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
--->
Subcase: Rupture of tension steel
--->
v* < v*sy2 - LHS eq.(4.5) is not satisfied
--->
v* < v*sc - LHS eq.(4.5) is not satisfied
--->
Subcase rejected
--->
New Subcase: Failure of compression zone
--->

```

$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied

--->

$$*cu(4.12) = 0.51649622$$

$$MRo(4.16) = 1.3727E+008$$

--->

$$u = cu(4.2) = 3.2469244E-005$$

$$Mu = MRo$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Mu_2 -

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$

$$Mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$co(5A.5, TBDY) = 0.002$$

$$\text{Final value of } cu: cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } cu = 0.01053874$$

$$w_e(5.4c) = 0.03096488$$

$$ase((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$$

$$ase1 = 0.16608997$$

$$bo_1 = 170.00$$

$$ho_1 = 170.00$$

$$bi2_1 = 115600.00$$

$$ase2 = \text{Max}(ase1, ase2) = 0.16608997$$

$$bo_2 = 92.00$$

$$ho_2 = 92.00$$

$$bi2_2 = 33856.00$$

$$psh, \min * F_{ywe} = \text{Min}(psh, x * F_{ywe}, psh, y * F_{ywe}) = 6.15233$$

 $psh, x * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

No stirups, $ns_1 = 2.00$

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

No stirups, $ns_2 = 2.00$

$$h2 = 100.00$$

 $psh, y * F_{ywe} = psh1 * F_{ywe1} + ps2 * F_{ywe2} = 6.15233$

$$ps1(\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$$

$$Ash1 = Astir_1 * ns_1 = 157.0796$$

No stirups, $ns_1 = 2.00$

$$h1 = 200.00$$

$$ps2(\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$$

$$Ash2 = Astir_2 * ns_2 = 100.531$$

No stirups, $ns_2 = 2.00$

$$h2 = 100.00$$

 $A_{sec} = 40000.00$

s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/ld = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764

2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764

v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00
d = 157.00
d' = 13.00

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

$$2 = A_{sl,com}/(b*d)*(f_s2/f_c) = 0.77530517$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->
 $v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->
 $v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

---->
Case/Assumption Rejected.

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->
 $v < v_{s,y1}$ - LHS eq.(4.7) is not satisfied

---->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->
 ρ_{cu} (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: 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} , ρ_{cc} , used in lieu of f_c , ρ_{cu}

---->
Subcase: Rupture of tension steel

---->
 $v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->
 $v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

---->
Subcase rejected

---->
New Subcase: Failure of compression zone

---->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied

---->
 ρ^*_{cu} (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

---->
 $u = \rho_{cu}$ (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$

$V_{r1} = V_{Co1}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Co10}$
 $V_{Co10} = 200506.935$
 $k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_{s+} + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $k_{nl} = 1$ (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 = 2.0213315E-011
Vu = 1.9686856E-030
d = 0.8*h = 160.00
Nu = 219397.073
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457
where:
Vs1 = 139627.457 is calculated for jacket, with:
d = 160.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.625
Vs2 = 0.00 is calculated for core, with:
d = 80.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

Calculation of Shear Strength at edge 2, Vr2 = 200506.935
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 200506.935
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc'^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
Mu = 2.0213315E-011
Vu = 1.9686856E-030
d = 0.8*h = 160.00
Nu = 219397.073
Ag = 40000.00
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 139627.457
where:
Vs1 = 139627.457 is calculated for jacket, with:
d = 160.00
Av = 157079.633
fy = 555.56
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.625
Vs2 = 0.00 is calculated for core, with:
d = 80.00
Av = 100530.965
fy = 555.56
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\gamma = 1.00$

Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.

Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_b/d \geq 1$)

No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -1.3301E+008$

Shear Force, $V_2 = -37594.437$

Shear Force, $V_3 = 6.2539570E-011$

Axial Force, $F = -218084.658$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{sl,t} = 2001.195$

-Compression: $A_{sl,c} = 1291.195$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten} = 983.3185$

-Compression: $A_{sl,com} = 983.3185$

-Middle: $A_{sl,mid} = 1325.752$

Longitudinal External Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,jacket} = 829.3805$

-Compression: $A_{sl,com,jacket} = 829.3805$

-Middle: $A_{sl,mid,jacket} = 402.1239$

Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{sl,ten,core} = 153.938$

-Compression: $A_{sl,com,core} = 153.938$

-Middle: $A_{sl,mid,core} = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 17.50$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u_{,R} = 1.0^*$ $u = 0.12513318$

$u = \gamma + \rho = 0.12513318$

- Calculation of y -

$$y = (M_y * L_s / 3) / E_{eff} = 0.09097686 \text{ ((4.29), Biskinis Phd)}$$

$$M_y = 1.0143E+008$$

$$L_s = M/V \text{ (with } L_s > 0.1 * L \text{ and } L_s < 2 * L) = 3537.917$$

$$\text{From table 10.5, ASCE 41_17: } E_{eff} = \text{factor} * E_c * I_g = 1.3147E+012$$

$$\text{factor} = 0.36521565$$

$$A_g = 40000.00$$

$$\text{Mean concrete strength: } f_c' = (f_c'_{\text{jacket}} * A_{\text{jacket}} + f_c'_{\text{core}} * A_{\text{core}}) / A_{\text{section}} = 33.00$$

$$N = 218084.658$$

$$E_c * I_g = E_c_{\text{jacket}} * I_{g_{\text{jacket}}} + E_c_{\text{core}} * I_{g_{\text{core}}} = 3.5999E+012$$

Calculation of Yielding Moment M_y

Calculation of y and M_y according to Annex 7 -

$$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$$

$$y_{\text{ten}} = 3.1087819E-005$$

$$\text{with } f_y = 555.56$$

$$d = 172.00$$

$$y = 0.48050392$$

$$A = 0.1071203$$

$$B = 0.06705607$$

$$\text{with } p_t = 0.02858484$$

$$p_c = 0.02858484$$

$$p_v = 0.03853931$$

$$N = 218084.658$$

$$b = 200.00$$

$$" = 0.1627907$$

$$y_{\text{comp}} = 2.6249185E-005$$

$$\text{with } f_c = 33.00$$

$$E_c = 26999.444$$

$$y = 0.48728983$$

$$A = 0.08130094$$

$$B = 0.05564476$$

$$\text{with } E_s = 200000.00$$

Calculation of ratio I_b/I_d

Adequate Lap Length: $I_b/I_d \geq 1$

- Calculation of p -

$$\text{From table 10-8: } p = 0.03415631$$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $I_b/I_d \geq 1$

$$\text{shear control ratio } V_y E / V_{col} O E = 0.4563967$$

$$d = d_{\text{external}} = 172.00$$

$$s = s_{\text{external}} = 150.00$$

$$t = s_1 + s_2 + 2 * t_f / b_w * (f_f e / f_s) = 0.00885929$$

$$\text{jacket: } s_1 = A_{v1} * h_1 / (s_1 * A_g) = 0.00785398$$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$$h_1 = 200.00$$

$$s_1 = 100.00$$

$$\text{core: } s_2 = A_{v2} * h_2 / (s_2 * A_g) = 0.00100531$$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$$h_2 = 100.00$$

$$s_2 = 250.00$$

The term $2 * t_f / b_w * (f_f e / f_s)$ 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 $f_f e / f_s$ 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.

$$NUD = 218084.658$$

$$A_g = 40000.00$$

$$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 33.00$$

$$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$$

$$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot s_1 + f_{y_int_Trans_Reinf} \cdot s_2) / (s_1 + s_2) = 555.56$$

$$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.09570899$$

$$b = 200.00$$

$$d = 172.00$$

$$f_{cE} = 33.00$$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (a)

Calculation No. 13

column C1, Floor 1

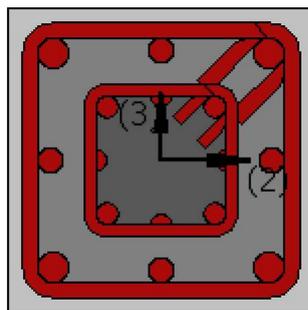
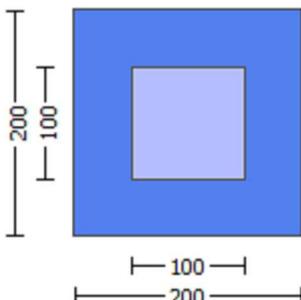
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity VR_d

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{c_lower_bound} = 25.00$

New material of Secondary Member: Steel Strength, $f_s = f_{s_lower_bound} = 500.00$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of 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, $c = 10.00$

Element Length, $L = 3000.00$

Secondary Member

Smooth Bars

Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)

Longitudinal Bars With Ends Lapped Starting at the End Sections

Adequate Lap Length ($l_o/l_{ou,min} = l_b/l_d \geq 1$)

No FRP Wrapping

Stepwise Properties

EDGE -A-

Bending Moment, $M_a = -1.3301E+008$

Shear Force, $V_a = -37594.437$

EDGE -B-

Bending Moment, $M_b = -7.4968E+006$

Shear Force, $V_b = 37594.437$

BOTH EDGES

Axial Force, $F = -218084.658$

Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: $A_{st} = 0.00$

-Compression: $A_{sc} = 3292.389$

Longitudinal Reinforcement Area Distribution (in 3 divisions)

-Tension: $A_{s,ten} = 983.3185$

-Compression: $A_{s,com} = 983.3185$

-Middle: $A_{s,mid} = 1325.752$

Mean Diameter of Tension Reinforcement, $Db_{L,ten} = 17.50$

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 175388.999$

V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{CoI} = 175388.999$

$V_{CoI} = 177628.325$

$k_n = 0.98739319$

displacement_ductility_demand = 2.16809

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '

where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 25.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 7.4968E+006$

$V_u = 37594.437$

$d = 0.8 \cdot h = 160.00$

$N_u = 218084.658$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$

where:

$V_{s1} = 125663.706$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 500.00$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 500.00$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 106288.613$

$b_w = 200.00$

displacement ductility demand is calculated as δ / y

- Calculation of δ / y for END B -

for rotation axis 3 and integ. section (b)

From analysis, chord rotation $\theta = 0.01672561$

$y = (M_y \cdot L_s / 3) / E_{\text{eff}} = 0.00771444$ ((4.29), Biskinis Phd)

$M_y = 1.0143E+008$

$L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 300.00

From table 10.5, ASCE 41_17: $E_{\text{eff}} = \text{factor} \cdot E_c \cdot I_g = 1.3147E+012$

factor = 0.36521565

$A_g = 40000.00$

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$

$N = 218084.658$

$E_c \cdot I_g = E_{c_{\text{jacket}}} \cdot I_{g_{\text{jacket}}} + E_{c_{\text{core}}} \cdot I_{g_{\text{core}}} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{\text{ten}}, y_{\text{com}})$

$y_{\text{ten}} = 3.1087819E-005$

with $f_y = 555.56$

$d = 172.00$

$y = 0.48050392$

$A = 0.1071203$

$B = 0.06705607$

with $pt = 0.02858484$

$pc = 0.02858484$

$pv = 0.03853931$

$N = 218084.658$

$b = 200.00$

" = 0.1627907
y_comp = 2.6249185E-005
with fc = 33.00
Ec = 26999.444
y = 0.48728983
A = 0.08130094
B = 0.05564476
with Es = 200000.00

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 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

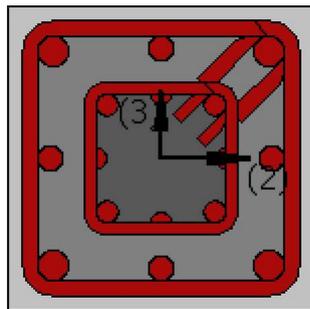
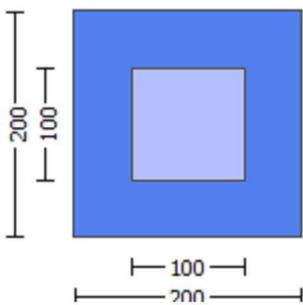
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)



Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 3
(Bending local axis: 2)

Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

```

Jacket
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
Existing Column
New material of Secondary Member: Concrete Strength,  $f_c = f_{cm} = 33.00$ 
New material of Secondary Member: Steel Strength,  $f_s = f_{sm} = 555.56$ 
Concrete Elasticity,  $E_c = 26999.444$ 
Steel Elasticity,  $E_s = 200000.00$ 
#####
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
Existing Column
New material: Steel Strength,  $f_s = 1.25 \cdot f_{sm} = 694.45$ 
#####
External Height,  $H = 200.00$ 
External Width,  $W = 200.00$ 
Internal Height,  $H = 100.00$ 
Internal Width,  $W = 100.00$ 
Cover Thickness,  $c = 10.00$ 
Mean Confinement Factor overall section = 1.06329
Element Length,  $L = 3000.00$ 
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{ou}, \min >= 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
At local axis: 3
EDGE -A-
Shear Force,  $V_a = -8.1187678E-030$ 
EDGE -B-
Shear Force,  $V_b = 8.1187678E-030$ 
BOTH EDGES
Axial Force,  $F = -219397.073$ 
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension:  $A_{st} = 0.00$ 
-Compression:  $A_{sc} = 3292.389$ 
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension:  $A_{st,ten} = 983.3185$ 
-Compression:  $A_{sc,com} = 983.3185$ 
-Middle:  $A_{st,mid} = 1325.752$ 
-----
-----

Calculation of Shear Capacity ratio,  $V_e/V_r = 0.4563967$ 
Member Controlled by Flexure ( $V_e/V_r < 1$ )
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14  $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$ 
with
 $M_{pr1} = \text{Max}(M_{u1+}, M_{u1-}) = 1.3727E+008$ 
 $M_{u1+} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u1-} = 1.3727E+008$ , is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(M_{u2+}, M_{u2-}) = 1.3727E+008$ 
 $M_{u2+} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the static loading combination
 $M_{u2-} = 1.3727E+008$ , is the ultimate moment strength at the edge 2 of the member in the opposite moment

```

direction which is defined for the the static loading combination

Calculation of Mu1+

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:

$$\phi_u = 3.2469244E-005$$

$$M_u = 1.3727E+008$$

with full section properties:

$$b = 200.00$$

$$d = 172.00$$

$$d' = 28.00$$

$$v = 0.19326733$$

$$N = 219397.073$$

$$f_c = 33.00$$

$$c_o \text{ (5A.5, TBDY)} = 0.002$$

$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01053874$$

$$w_e \text{ (5.4c)} = 0.03096488$$

$$a_{se} \text{ ((5.4d), TBDY)} = (a_{se1} * A_{ext} + a_{se2} * A_{int}) / A_{sec} = 0.16608997$$

$$a_{se1} = 0.16608997$$

$$b_{o_1} = 170.00$$

$$h_{o_1} = 170.00$$

$$b_{i2_1} = 115600.00$$

$$a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$$

$$b_{o_2} = 92.00$$

$$h_{o_2} = 92.00$$

$$b_{i2_2} = 33856.00$$

$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{sh2} * F_{ywe2} = 6.15233$$

$$p_{sh1} \text{ (external)} = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$

$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

$$\text{No stirups, } n_{s_1} = 2.00$$

$$h_1 = 200.00$$

$$p_{sh2} \text{ (internal)} = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$

$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

$$\text{No stirups, } n_{s_2} = 2.00$$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$

$$s_1 = 100.00$$

$$s_2 = 250.00$$

$$f_{ywe1} = 694.45$$

$$f_{ywe2} = 694.45$$

$$f_{ce} = 33.00$$

$$\text{From ((5.A.5), TBDY), TBDY: } c_c = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y_1 = 0.0025$$

$$sh_1 = 0.008$$

$$ft_1 = 833.34$$

$$fy_1 = 694.45$$

$$su_1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/d = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, 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 $\text{Min}(1, 1.25 \cdot (lb/d)^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764

2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764

v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00

d = 157.00

d' = 13.00

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

--->

v < vs,c - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

satisfies Eq. (4.4)
 --->
 $v < s_y1$ - LHS eq.(4.7) is not satisfied
 --->
 $v < v_{c,y1}$ - RHS eq.(4.6) is satisfied
 --->
 c_u (4.10) = 0.45915168
 M_{Rc} (4.17) = 1.5179E+008
 --->
 New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
 In expressions below, the following modifications have been made
 - b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o
 - $N, \epsilon_1, \epsilon_2, v$ 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 satisfied
 --->
 c_u^* (4.12) = 0.51649622
 M_{Ro} (4.16) = 1.3727E+008
 --->
 $u = c_u$ (4.2) = 3.2469244E-005
 $\mu_u = M_{Ro}$

 Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of μ_{u1} -

 Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

$u = 3.2469244E-005$
 $\mu_u = 1.3727E+008$

with full section properties:

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 ϵ_{co} (5A.5, TBDY) = 0.002
 Final value of c_u : $c_u^* = \text{shear_factor} * \text{Max}(c_u, \epsilon_{cc}) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $c_u = 0.01053874$
 w_e (5.4c) = 0.03096488
 a_{se} ((5.4d), TBDY) = $(a_{se1}*A_{ext} + a_{se2}*A_{int})/A_{sec} = 0.16608997$
 $a_{se1} = 0.16608997$
 $b_{o_1} = 170.00$
 $h_{o_1} = 170.00$
 $b_{i2_1} = 115600.00$
 $a_{se2} = \text{Max}(a_{se1}, a_{se2}) = 0.16608997$
 $b_{o_2} = 92.00$

ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su1 = 0.4*esu1_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu1_nominal = 0.08,

For calculation of esu1_nominal and y1, sh1,ft1,fy1, it is considered
characteristic value fsy1 = fs1/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 694.45

with Es1 = (Es,jacket*Asl,ten,jacket + Es,core*Asl,ten,core)/Asl,ten = 200000.00

y2 = 0.0025
sh2 = 0.008
ft2 = 833.34
fy2 = 694.45
su2 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,min = 1.00

su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032

From table 5A.1, TBDY: esu2_nominal = 0.08,

For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.

y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/lb,min)^ 2/3), from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45

with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00

yv = 0.0025
shv = 0.008
ftv = 833.34

```

fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^ 2/3), from 10.3.5, ASCE 41-17.
with fsv = (fsjacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->
Subcase: Rupture of tension steel
---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied
---->
v* < v*s,c - LHS eq.(4.5) is not satisfied
---->
Subcase rejected
---->
New Subcase: Failure of compression zone
---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied
---->
*cu (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008
---->

```

$$u = c_u(4.2) = 3.2469244E-005$$
$$\mu = M_{Ro}$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of μ_{2+}

Calculation of ultimate curvature μ according to 4.1, Biskinis/Fardis 2013:

$$u = 3.2469244E-005$$
$$\mu = 1.3727E+008$$

with full section properties:

$$b = 200.00$$
$$d = 172.00$$
$$d' = 28.00$$
$$v = 0.19326733$$
$$N = 219397.073$$
$$f_c = 33.00$$
$$c_o(5A.5, TBDY) = 0.002$$
$$\text{Final value of } c_u: c_u^* = \text{shear_factor} * \text{Max}(c_u, c_c) = 0.01053874$$

The Shear_factor is considered equal to 1 (pure moment strength)

$$\text{From (5.4b), TBDY: } c_u = 0.01053874$$
$$w_e(5.4c) = 0.03096488$$
$$\text{ase ((5.4d), TBDY) = (ase1*A_{ext} + ase2*A_{int})/A_{sec} = 0.16608997}$$
$$\text{ase1} = 0.16608997$$
$$b_{o_1} = 170.00$$
$$h_{o_1} = 170.00$$
$$b_{i2_1} = 115600.00$$
$$\text{ase2} = \text{Max}(\text{ase1}, \text{ase2}) = 0.16608997$$
$$b_{o_2} = 92.00$$
$$h_{o_2} = 92.00$$
$$b_{i2_2} = 33856.00$$
$$p_{sh, \min} * F_{ywe} = \text{Min}(p_{sh, x} * F_{ywe}, p_{sh, y} * F_{ywe}) = 6.15233$$

$$p_{sh, x} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$
$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$
$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

No stirups, $n_{s_1} = 2.00$

$$h_1 = 200.00$$
$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$
$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

No stirups, $n_{s_2} = 2.00$

$$h_2 = 100.00$$

$$p_{sh, y} * F_{ywe} = p_{sh1} * F_{ywe1} + p_{s2} * F_{ywe2} = 6.15233$$
$$p_{s1}(\text{external}) = (A_{sh1} * h_1 / s_1) / A_{sec} = 0.00785398$$
$$A_{sh1} = A_{stir_1} * n_{s_1} = 157.0796$$

No stirups, $n_{s_1} = 2.00$

$$h_1 = 200.00$$
$$p_{s2}(\text{internal}) = (A_{sh2} * h_2 / s_2) / A_{sec} = 0.00100531$$
$$A_{sh2} = A_{stir_2} * n_{s_2} = 100.531$$

No stirups, $n_{s_2} = 2.00$

$$h_2 = 100.00$$

$$A_{sec} = 40000.00$$
$$s_1 = 100.00$$
$$s_2 = 250.00$$
$$f_{ywe1} = 694.45$$
$$f_{ywe2} = 694.45$$
$$f_{ce} = 33.00$$

From ((5.A.5), TBDY), TBDY: $cc = 0.00263293$
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$lo/lou,min = lb/ld = 1.00$

$su1 = 0.4 * esu1_nominal ((5.5), TBDY) = 0.032$

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
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
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 $Es_v = (Es,jacket * Asl,mid,jacket + Es,mid * Asl,mid,core) / Asl,mid = 200000.00$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.60153764$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.60153764$

$v = Asl,mid / (b * d) * (fsv / fc) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$fcc (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$1 = Asl,ten / (b * d) * (fs1 / fc) = 0.77530517$

$2 = Asl,com / (b * d) * (fs2 / fc) = 0.77530517$

$v = Asl,mid / (b * d) * (fsv / fc) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

v < vs,y2 - LHS eq.(4.5) is not satisfied

---->

v < vs,c - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)

---->

v < vs,y1 - LHS eq.(4.7) is not satisfied

---->

v < vc,y1 - RHS eq.(4.6) is satisfied

---->

cu (4.10) = 0.45915168

MRC (4.17) = 1.5179E+008

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o

- N, ϵ_1 , ϵ_2 , v normalised to bo*do, instead of b*d

- parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

---->

Subcase: Rupture of tension steel

---->

v* < v*s,y2 - LHS eq.(4.5) is not satisfied

---->

v* < v*s,c - LHS eq.(4.5) is not satisfied

---->

Subcase rejected

---->

New Subcase: Failure of compression zone

---->

v* < v*c,y2 - LHS eq.(4.6) is satisfied

---->

*cu (4.12) = 0.51649622

MRO (4.16) = 1.3727E+008

---->

u = cu (4.2) = 3.2469244E-005

Mu = MRO

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00
fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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 $f_{s2} = f_{s2}/1.2$, 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 $f_{s2} = (f_{s,jacket} \cdot A_{s,com,jacket} + f_{s,core} \cdot A_{s,com,core})/A_{s,com} = 694.45$

with $E_{s2} = (E_{s,jacket} \cdot A_{s,com,jacket} + E_{s,core} \cdot A_{s,com,core})/A_{s,com} = 200000.00$

$y_v = 0.0025$

$sh_v = 0.008$

$ft_v = 833.34$

$f_{y_v} = 694.45$

$s_{u_v} = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor

and also multiplied by the shear_factor according to 15.7.1.4, with

Shear_factor = 1.00

$l_o/l_{o,min} = l_b/l_d = 1.00$

$s_{u_v} = 0.4 \cdot e_{s_{u_v,nominal}} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $e_{s_{u_v,nominal}} = 0.08$,

considering characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY

For calculation of $e_{s_{u_v,nominal}}$ and y_v, sh_v, ft_v, f_{y_v} , it is considered

characteristic value $f_{s_{y_v}} = f_{s_v}/1.2$, from table 5.1, TBDY.

y_1, sh_1, ft_1, f_{y1} , are also multiplied by $\text{Min}(1, 1.25 \cdot (l_b/l_d)^{2/3})$, from 10.3.5, ASCE 41-17.

with $f_{s_v} = (f_{s,jacket} \cdot A_{s,mid,jacket} + f_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 694.45$

with $E_{s_v} = (E_{s,jacket} \cdot A_{s,mid,jacket} + E_{s,mid} \cdot A_{s,mid,core})/A_{s,mid} = 200000.00$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.60153764$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.60153764$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

$f_{cc} (5A.2, TBDY) = 35.08866$

$cc (5A.5, TBDY) = 0.00263293$

$c = \text{confinement factor} = 1.06329$

$1 = A_{s,ten}/(b \cdot d) \cdot (f_{s1}/f_c) = 0.77530517$

$2 = A_{s,com}/(b \cdot d) \cdot (f_{s2}/f_c) = 0.77530517$

$v = A_{s,mid}/(b \cdot d) \cdot (f_{s_v}/f_c) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

--->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

--->

Case/Assumption Rejected.

--->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

--->

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

--->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

--->

$c_u (4.10) = 0.45915168$

$M_{Rc} (4.17) = 1.5179E+008$

--->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o

- $N, 1, 2, v$ normalised to $b_o \cdot d_o$, instead of $b \cdot d$

- f_{cc}, cc 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 satisfied

--->

$*c_u$ (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

--->

$u = c_u$ (4.2) = 3.2469244E-005

$\mu = M_{Ro}$

Calculation of ratio l_b/d

Adequate Lap Length: $l_b/d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$

$V_{r1} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$V_{Col0} = 200506.935$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)
Mean concrete strength: $f'_c = (f'_{c_jacket} * \text{Area}_{jacket} + f'_{c_core} * \text{Area}_{core}) / \text{Area}_{section} = 33.00$, but $f'_c^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/d = 2.00$

$\mu_u = 4.0616465E-011$

$V_u = 8.1187678E-030$

$d = 0.8 * h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 200506.935$

$V_{r2} = V_{Col}$ ((10.3), ASCE 41-17) = $k_{nl} * V_{Col0}$

$V_{Col0} = 200506.935$

$k_{nl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v * f_y * d / s$ ' is replaced by ' $V_s + f * V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

 $= 1$ (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$, but $f_c'^{0.5} \leq 8.3$ MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 4.0616465E-011$

$\nu_u = 8.1187678E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $Col1 = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $Col2 = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$b_w = 200.00$

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1

At Shear local axis: 2

(Bending local axis: 3)

Section Type: rcjrs

Constant Properties

Knowledge Factor, $\phi = 1.00$

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

Existing Column

New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$

New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$

Concrete Elasticity, $E_c = 26999.444$

Steel Elasticity, $E_s = 200000.00$

#####

Note: Especially for the calculation of moment strengths,

the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14

Jacket

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

Existing Column

New material: Steel Strength, $f_s = 1.25 \cdot f_{sm} = 694.45$

#####

External Height, $H = 200.00$

External Width, $W = 200.00$

Internal Height, $H = 100.00$

Internal Width, $W = 100.00$

Cover Thickness, $c = 10.00$
Mean Confinement Factor overall section = 1.06329
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_o/l_{ou}, \min >= 1$)
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, $V_a = -1.9686856E-030$
EDGE -B-
Shear Force, $V_b = 1.9686856E-030$
BOTH EDGES
Axial Force, $F = -219397.073$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3292.389$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 983.3185$
-Compression: $As_{c,com} = 983.3185$
-Middle: $As_{mid} = 1325.752$

Calculation of Shear Capacity ratio, $V_e/V_r = 0.4563967$
Member Controlled by Flexure ($V_e/V_r < 1$)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 $V_e = (M_{pr1} + M_{pr2})/l_n = 91510.703$
with
 $M_{pr1} = \text{Max}(Mu_{1+}, Mu_{1-}) = 1.3727E+008$
 $Mu_{1+} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{1-} = 1.3727E+008$, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
 $M_{pr2} = \text{Max}(Mu_{2+}, Mu_{2-}) = 1.3727E+008$
 $Mu_{2+} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the static loading combination
 $Mu_{2-} = 1.3727E+008$, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the static loading combination

Calculation of Mu_{1+}

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $\phi_u = 3.2469244E-005$
 $Mu = 1.3727E+008$

with full section properties:

$b = 200.00$
 $d = 172.00$
 $d' = 28.00$
 $v = 0.19326733$
 $N = 219397.073$
 $f_c = 33.00$
 ϕ_o (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_o) = 0.01053874$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.01053874$

we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = Max(ase1,ase2) = 0.16608997
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233
ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398
Ash1 = Astir_1*ns_1 = 157.0796
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531
Ash2 = Astir_2*ns_2 = 100.531
No stirups, ns_2 = 2.00
h2 = 100.00

Asec = 40000.00
s1 = 100.00
s2 = 250.00

fywe1 = 694.45
fywe2 = 694.45
fce = 33.00

From ((5.A5), TBDY), TBDY: cc = 0.00263293
c = confinement factor = 1.06329

y1 = 0.0025
sh1 = 0.008
ft1 = 833.34
fy1 = 694.45
su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/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 = (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 , $sh_{2,ft2, fy2}$, it is considered characteristic value $fs_{y2} = fs_2/1.2$, from table 5.1, TBDY.

y_1 , $sh_{1,ft1, fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_2 = (fs_{jacket} \cdot Asl_{,com,jacket} + fs_{core} \cdot Asl_{,com,core}) / Asl_{,com} = 694.45$

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

$lo/lo_{u,min} = lb/ld = 1.00$

$suv = 0.4 \cdot es_{uv_nominal} ((5.5), TBDY) = 0.032$

From table 5A.1, TBDY: $es_{uv_nominal} = 0.08$,

considering characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY

For calculation of $es_{uv_nominal}$ and y_v , sh_v, ft_v, fy_v , it is considered characteristic value $fs_{yv} = fs_v/1.2$, from table 5.1, TBDY.

y_1 , $sh_{1,ft1, fy1}$, are also multiplied by $\text{Min}(1, 1.25 \cdot (lb/ld)^{2/3})$, from 10.3.5, ASCE 41-17.

with $fs_v = (fs_{jacket} \cdot Asl_{,mid,jacket} + fs_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 694.45$

with $Es_v = (Es_{jacket} \cdot Asl_{,mid,jacket} + Es_{mid} \cdot Asl_{,mid,core}) / Asl_{,mid} = 200000.00$

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.60153764$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.60153764$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 0.8110188$

and confined core properties:

$b = 170.00$

$d = 157.00$

$d' = 13.00$

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

$1 = Asl_{,ten} / (b \cdot d) \cdot (fs_1 / fc) = 0.77530517$

$2 = Asl_{,com} / (b \cdot d) \cdot (fs_2 / fc) = 0.77530517$

$v = Asl_{,mid} / (b \cdot d) \cdot (fs_v / fc) = 1.0453$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

Case/Assumption Rejected.

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

cu (4.10) = 0.45915168

MRC (4.17) = 1.5179E+008

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b , d , d' replaced by geometric parameters of the core: bo , do , $d'o$

- N , 1 , 2 , v normalised to $bo \cdot do$, instead of $b \cdot d$

- f , c parameters of confined concrete, fcc , cc , used in lieu of fc , ecu

Subcase: Rupture of tension steel

$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

Subcase rejected

--->
New Subcase: Failure of compression zone

--->
 $v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied

--->
 $*c_u$ (4.12) = 0.51649622
MRo (4.16) = 1.3727E+008

--->
 $u = c_u$ (4.2) = 3.2469244E-005
Mu = MRo

Calculation of ratio lb/ld

Adequate Lap Length: lb/ld \geq 1

Calculation of Mu1-

Calculation of ultimate curvature ϕ_u according to 4.1, Biskinis/Fardis 2013:
 $u = 3.2469244E-005$
Mu = 1.3727E+008

with full section properties:

b = 200.00
d = 172.00
d' = 28.00
v = 0.19326733
N = 219397.073

fc = 33.00
co (5A.5, TBDY) = 0.002
Final value of ϕ_u : $\phi_u^* = \text{shear_factor} * \text{Max}(\phi_u, \phi_c) = 0.01053874$
The Shear_factor is considered equal to 1 (pure moment strength)
From (5.4b), TBDY: $\phi_u = 0.01053874$

we (5.4c) = 0.03096488
ase ((5.4d), TBDY) = $(ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
ase1 = 0.16608997
bo_1 = 170.00
ho_1 = 170.00
bi2_1 = 115600.00
ase2 = $\text{Max}(ase1, ase2) = 0.16608997$
bo_2 = 92.00
ho_2 = 92.00
bi2_2 = 33856.00
psh,min*Fywe = $\text{Min}(psh,x * Fywe, psh,y * Fywe) = 6.15233$

psh_x*Fywe = $psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
Ash1 = $A_{stir_1} * ns_1 = 157.0796$
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
Ash2 = $A_{stir_2} * ns_2 = 100.531$
No stirups, ns_2 = 2.00
h2 = 100.00

psh_y*Fywe = $psh1 * Fywe1 + ps2 * Fywe2 = 6.15233$
ps1 (external) = $(Ash1 * h1 / s1) / A_{sec} = 0.00785398$
Ash1 = $A_{stir_1} * ns_1 = 157.0796$
No stirups, ns_1 = 2.00
h1 = 200.00
ps2 (internal) = $(Ash2 * h2 / s2) / A_{sec} = 0.00100531$
Ash2 = $A_{stir_2} * ns_2 = 100.531$
No stirups, ns_2 = 2.00

h2 = 100.00

Asec = 40000.00

s1 = 100.00

s2 = 250.00

fywe1 = 694.45

fywe2 = 694.45

fce = 33.00

From ((5.A.5), TBDY), TBDY: cc = 0.00263293

c = confinement factor = 1.06329

y1 = 0.0025

sh1 = 0.008

ft1 = 833.34

fy1 = 694.45

su1 = 0.032

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

lo/lou,min = lb/lb,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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs1 = (fs,jacket*Asl,ten,jacket + fs,core*Asl,ten,core)/Asl,ten = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 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 $\text{Min}(1, 1.25 \cdot (\text{lb}/\text{ld})^{2/3})$, from 10.3.5, ASCE 41-17.

with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45

with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00

1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764

2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764

v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188

and confined core properties:

b = 170.00

d = 157.00

d' = 13.00

fcc (5A.2, TBDY) = 35.08866

cc (5A.5, TBDY) = 0.00263293

c = confinement factor = 1.06329

1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517

2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517

v = Asl,mid/(b*d)*(fsv/fc) = 1.0453

Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)

---->
v < vs,y2 - LHS eq.(4.5) is not satisfied

---->
v < vs,c - RHS eq.(4.5) is not satisfied

---->
Case/Assumption Rejected.

---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)

---->
v < s,y1 - LHS eq.(4.7) is not satisfied

---->
v < vc,y1 - RHS eq.(4.6) is satisfied

---->
cu (4.10) = 0.45915168

MRC (4.17) = 1.5179E+008

---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu

---->
Subcase: Rupture of tension steel

---->
v* < v*s,y2 - LHS eq.(4.5) is not satisfied

---->
v* < v*s,c - LHS eq.(4.5) is not satisfied

---->
Subcase rejected

---->
New Subcase: Failure of compression zone

---->
v* < v*c,y2 - LHS eq.(4.6) is satisfied

---->
*cu (4.12) = 0.51649622

MRO (4.16) = 1.3727E+008

---->
u = cu (4.2) = 3.2469244E-005
Mu = MRO

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2+

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:
u = 3.2469244E-005
Mu = 1.3727E+008

with full section properties:
b = 200.00
d = 172.00
d' = 28.00

$v = 0.19326733$
 $N = 219397.073$
 $fc = 33.00$
 $co (5A.5, TBDY) = 0.002$
 Final value of cu : $cu^* = \text{shear_factor} * \text{Max}(cu, cc) = 0.01053874$
 The Shear_factor is considered equal to 1 (pure moment strength)
 From (5.4b), TBDY: $cu = 0.01053874$
 $we (5.4c) = 0.03096488$
 $ase ((5.4d), TBDY) = (ase1 * A_{ext} + ase2 * A_{int}) / A_{sec} = 0.16608997$
 $ase1 = 0.16608997$
 $bo_1 = 170.00$
 $ho_1 = 170.00$
 $bi2_1 = 115600.00$
 $ase2 = \text{Max}(ase1, ase2) = 0.16608997$
 $bo_2 = 92.00$
 $ho_2 = 92.00$
 $bi2_2 = 33856.00$
 $psh, \text{min} * Fy_{we} = \text{Min}(psh, x * Fy_{we}, psh, y * Fy_{we}) = 6.15233$

$psh, x * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 6.15233$
 $ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$psh, y * Fy_{we} = psh1 * Fy_{we1} + ps2 * Fy_{we2} = 6.15233$
 $ps1 (\text{external}) = (Ash1 * h1 / s1) / A_{sec} = 0.00785398$
 $Ash1 = Astir_1 * ns_1 = 157.0796$
 No stirups, $ns_1 = 2.00$
 $h1 = 200.00$
 $ps2 (\text{internal}) = (Ash2 * h2 / s2) / A_{sec} = 0.00100531$
 $Ash2 = Astir_2 * ns_2 = 100.531$
 No stirups, $ns_2 = 2.00$
 $h2 = 100.00$

$A_{sec} = 40000.00$
 $s1 = 100.00$
 $s2 = 250.00$
 $fy_{we1} = 694.45$
 $fy_{we2} = 694.45$
 $f_{ce} = 33.00$

From ((5.A.5), TBDY), TBDY: $cc = 0.00263293$
 $c = \text{confinement factor} = 1.06329$

$y1 = 0.0025$
 $sh1 = 0.008$
 $ft1 = 833.34$
 $fy1 = 694.45$
 $su1 = 0.032$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
 and also multiplied by the shear_factor according to 15.7.1.4, with
 $\text{Shear_factor} = 1.00$

$lo/lo_{u, \text{min}} = lb/ld = 1.00$
 $su1 = 0.4 * esu1_{\text{nominal}} ((5.5), TBDY) = 0.032$

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/lou,min = lb/lb,min = 1.00
su2 = 0.4*esu2_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esu2_nominal = 0.08,
For calculation of esu2_nominal and y2, sh2,ft2,fy2, it is considered
characteristic value fsy2 = fs2/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fs2 = (fs,jacket*Asl,com,jacket + fs,core*Asl,com,core)/Asl,com = 694.45
with Es2 = (Es,jacket*Asl,com,jacket + Es,core*Asl,com,core)/Asl,com = 200000.00
yv = 0.0025
shv = 0.008
ftv = 833.34
fyv = 694.45
suv = 0.032
using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00
lo/lou,min = lb/ld = 1.00
suv = 0.4*esuv_nominal ((5.5), TBDY) = 0.032
From table 5A.1, TBDY: esuv_nominal = 0.08,
considering characteristic value fsyv = fsv/1.2, from table 5.1, TBDY
For calculation of esuv_nominal and yv, shv,ftv,fyv, it is considered
characteristic value fsyv = fsv/1.2, from table 5.1, TBDY.
y1, sh1,ft1,fy1, are also multiplied by Min(1,1.25*(lb/ld)^2/3), from 10.3.5, ASCE 41-17.
with fsv = (fs,jacket*Asl,mid,jacket + fs,mid*Asl,mid,core)/Asl,mid = 694.45
with Esv = (Es,jacket*Asl,mid,jacket + Es,mid*Asl,mid,core)/Asl,mid = 200000.00
1 = Asl,ten/(b*d)*(fs1/fc) = 0.60153764
2 = Asl,com/(b*d)*(fs2/fc) = 0.60153764
v = Asl,mid/(b*d)*(fsv/fc) = 0.8110188
and confined core properties:
b = 170.00
d = 157.00
d' = 13.00
fcc (5A.2, TBDY) = 35.08866
cc (5A.5, TBDY) = 0.00263293
c = confinement factor = 1.06329
1 = Asl,ten/(b*d)*(fs1/fc) = 0.77530517
2 = Asl,com/(b*d)*(fs2/fc) = 0.77530517
v = Asl,mid/(b*d)*(fsv/fc) = 1.0453
Case/Assumption: Unconfined full section - Steel rupture
' satisfies Eq. (4.3)
---->
v < vs,y2 - LHS eq.(4.5) is not satisfied
---->
v < vs,c - RHS eq.(4.5) is not satisfied
---->
Case/Assumption Rejected.
---->
New Case/Assumption: Unconfined full section - Spalling of concrete cover
' satisfies Eq. (4.4)
---->
v < s,y1 - LHS eq.(4.7) is not satisfied
---->
v < vc,y1 - RHS eq.(4.6) is satisfied
---->
cu (4.10) = 0.45915168
MRc (4.17) = 1.5179E+008
---->
New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover
In expressions below, the following modifications have been made
- b, d, d' replaced by geometric parameters of the core: bo, do, d'o
- N, 1, 2, v normalised to bo*do, instead of b*d
- - parameters of confined concrete, fcc, cc, used in lieu of fc, ecu
---->

```

Subcase: Rupture of tension steel

--->

$v^* < v^*_{s,y2}$ - LHS eq.(4.5) is not satisfied

--->

$v^* < v^*_{s,c}$ - LHS eq.(4.5) is not satisfied

--->

Subcase rejected

--->

New Subcase: Failure of compression zone

--->

$v^* < v^*_{c,y2}$ - LHS eq.(4.6) is satisfied

--->

*cu (4.12) = 0.51649622

M_{Ro} (4.16) = 1.3727E+008

--->

u = cu (4.2) = 3.2469244E-005

Mu = M_{Ro}

Calculation of ratio lb/d

Adequate Lap Length: lb/d >= 1

Calculation of Mu2-

Calculation of ultimate curvature u according to 4.1, Biskinis/Fardis 2013:

u = 3.2469244E-005

Mu = 1.3727E+008

with full section properties:

b = 200.00

d = 172.00

d' = 28.00

v = 0.19326733

N = 219397.073

fc = 33.00

co (5A.5, TBDY) = 0.002

Final value of cu: cu* = shear_factor * Max(cu, cc) = 0.01053874

The Shear_factor is considered equal to 1 (pure moment strength)

From (5.4b), TBDY: cu = 0.01053874

we (5.4c) = 0.03096488

ase ((5.4d), TBDY) = (ase1*Aext+ase2*Aint)/Asec = 0.16608997

ase1 = 0.16608997

bo_1 = 170.00

ho_1 = 170.00

bi2_1 = 115600.00

ase2 = Max(ase1,ase2) = 0.16608997

bo_2 = 92.00

ho_2 = 92.00

bi2_2 = 33856.00

psh,min*Fywe = Min(psh,x*Fywe , psh,y*Fywe) = 6.15233

psh_x*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233

ps1 (external) = (Ash1*h1/s1)/Asec = 0.00785398

Ash1 = Astir_1*ns_1 = 157.0796

No stirups, ns_1 = 2.00

h1 = 200.00

ps2 (internal) = (Ash2*h2/s2)/Asec = 0.00100531

Ash2 = Astir_2*ns_2 = 100.531

No stirups, ns_2 = 2.00

h2 = 100.00

psh_y*Fywe = psh1*Fywe1+ps2*Fywe2 = 6.15233

$$ps1 \text{ (external)} = (Ash1 \cdot h1 / s1) / Asec = 0.00785398$$

$$Ash1 = Astir_1 \cdot ns_1 = 157.0796$$

$$\text{No stirups, } ns_1 = 2.00$$

$$h1 = 200.00$$

$$ps2 \text{ (internal)} = (Ash2 \cdot h2 / s2) / Asec = 0.00100531$$

$$Ash2 = Astir_2 \cdot ns_2 = 100.531$$

$$\text{No stirups, } ns_2 = 2.00$$

$$h2 = 100.00$$

$$Asec = 40000.00$$

$$s1 = 100.00$$

$$s2 = 250.00$$

$$fywe1 = 694.45$$

$$fywe2 = 694.45$$

$$fce = 33.00$$

$$\text{From } ((5.A5), \text{ TBDY}), \text{ TBDY: } cc = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$y1 = 0.0025$$

$$sh1 = 0.008$$

$$ft1 = 833.34$$

$$fy1 = 694.45$$

$$su1 = 0.032$$

using (30) in Biskinis/Fardis (2013) multiplied with shear_factor
and also multiplied by the shear_factor according to 15.7.1.4, with
Shear_factor = 1.00

$$lo/lou, \text{min} = lb/ld = 1.00$$

$$su1 = 0.4 \cdot esu1_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu1_{\text{nominal}} = 0.08,$$

For calculation of $esu1_{\text{nominal}}$ and $y1, sh1, ft1, fy1$, it is considered
characteristic value $fsy1 = fs1/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs1 = (fs_{\text{jacket}} \cdot Asl, \text{ten, jacket} + fs_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 694.45$$

$$\text{with } Es1 = (Es_{\text{jacket}} \cdot Asl, \text{ten, jacket} + Es_{\text{core}} \cdot Asl, \text{ten, core}) / Asl, \text{ten} = 200000.00$$

$$y2 = 0.0025$$

$$sh2 = 0.008$$

$$ft2 = 833.34$$

$$fy2 = 694.45$$

$$su2 = 0.032$$

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

$$lo/lou, \text{min} = lb/lb, \text{min} = 1.00$$

$$su2 = 0.4 \cdot esu2_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esu2_{\text{nominal}} = 0.08,$$

For calculation of $esu2_{\text{nominal}}$ and $y2, sh2, ft2, fy2$, it is considered
characteristic value $fsy2 = fs2/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fs2 = (fs_{\text{jacket}} \cdot Asl, \text{com, jacket} + fs_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 694.45$$

$$\text{with } Es2 = (Es_{\text{jacket}} \cdot Asl, \text{com, jacket} + Es_{\text{core}} \cdot Asl, \text{com, core}) / Asl, \text{com} = 200000.00$$

$$yv = 0.0025$$

$$shv = 0.008$$

$$ftv = 833.34$$

$$fyv = 694.45$$

$$suv = 0.032$$

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

$$lo/lou, \text{min} = lb/ld = 1.00$$

$$suv = 0.4 \cdot esuv_{\text{nominal}} ((5.5), \text{ TBDY}) = 0.032$$

$$\text{From table 5A.1, TBDY: } esuv_{\text{nominal}} = 0.08,$$

considering characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY

For calculation of $esuv_{\text{nominal}}$ and yv, shv, ftv, fyv , it is considered
characteristic value $fsyv = fsv/1.2$, from table 5.1, TBDY.

$$y1, sh1, ft1, fy1, \text{ are also multiplied by } \text{Min}(1, 1.25 \cdot (lb/ld)^{2/3}), \text{ from 10.3.5, ASCE 41-17.}$$

$$\text{with } fsv = (fs_{\text{jacket}} \cdot Asl, \text{mid, jacket} + fs_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 694.45$$

$$\text{with } Esv = (Es_{\text{jacket}} \cdot Asl, \text{mid, jacket} + Es_{\text{mid}} \cdot Asl, \text{mid, core}) / Asl, \text{mid} = 200000.00$$

$$1 = Asl, \text{ten} / (b \cdot d) \cdot (fs1 / fce) = 0.60153764$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.60153764$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 0.8110188$$

and confined core properties:

$$b = 170.00$$

$$d = 157.00$$

$$d' = 13.00$$

$$f_{cc} (5A.2, TBDY) = 35.08866$$

$$c_c (5A.5, TBDY) = 0.00263293$$

$$c = \text{confinement factor} = 1.06329$$

$$1 = A_{sl,ten}/(b*d)*(f_{s1}/f_c) = 0.77530517$$

$$2 = A_{sl,com}/(b*d)*(f_{s2}/f_c) = 0.77530517$$

$$v = A_{sl,mid}/(b*d)*(f_{sv}/f_c) = 1.0453$$

Case/Assumption: Unconfined full section - Steel rupture

' satisfies Eq. (4.3)

---->

$v < v_{s,y2}$ - LHS eq.(4.5) is not satisfied

---->

$v < v_{s,c}$ - RHS eq.(4.5) is not satisfied

---->

Case/Assumption Rejected.

---->

New Case/Assumption: Unconfined full section - Spalling of concrete cover

' satisfies Eq. (4.4)

---->

$v < s_{y1}$ - LHS eq.(4.7) is not satisfied

---->

$v < v_{c,y1}$ - RHS eq.(4.6) is satisfied

---->

$$c_u (4.10) = 0.45915168$$

$$M_{Rc} (4.17) = 1.5179E+008$$

---->

New Case/Assumption: Ultimate curvature of confined core after spalling of concrete cover

In expressions below, the following modifications have been made

- b, d, d' replaced by geometric parameters of the core: b_o, d_o, d'_o

- $N, 1, 2, v$ normalised to b_o*d_o , instead of $b*d$

- - parameters of confined concrete, f_{cc}, c_c , used in lieu of f_c, 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 satisfied

---->

$$*c_u (4.12) = 0.51649622$$

$$M_{Ro} (4.16) = 1.3727E+008$$

---->

$$u = c_u (4.2) = 3.2469244E-005$$

$$M_u = M_{Ro}$$

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

Calculation of Shear Strength $V_r = \text{Min}(V_{r1}, V_{r2}) = 200506.935$

Calculation of Shear Strength at edge 1, $V_{r1} = 200506.935$

$$V_{r1} = V_{Col} ((10.3), ASCE 41-17) = k_{nl} * V_{ColO}$$

VCol0 = 200506.935
knl = 1 (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

V_{s2} is multiplied by $\text{Col2} = 0.00$

$s/d = 3.125$

V_f ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: $V_s + V_f \leq 122116.319$

$b_w = 200.00$

Calculation of Shear Strength at edge 2, $V_{r2} = 200506.935$

$V_{r2} = V_{\text{Col}} ((10.3), \text{ASCE } 41-17) = \text{knl} \cdot V_{\text{Col0}}$

$V_{\text{Col0}} = 200506.935$

$\text{knl} = 1$ (zero step-static loading)

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)

Mean concrete strength: $f_c' = (f_c'_{\text{jacket}} \cdot \text{Area}_{\text{jacket}} + f_c'_{\text{core}} \cdot \text{Area}_{\text{core}}) / \text{Area}_{\text{section}} = 33.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)

$M/Vd = 2.00$

$\mu_u = 2.0213315E-011$

$\nu_u = 1.9686856E-030$

$d = 0.8 \cdot h = 160.00$

$N_u = 219397.073$

$A_g = 40000.00$

From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 139627.457$

where:

$V_{s1} = 139627.457$ is calculated for jacket, with:

$d = 160.00$

$A_v = 157079.633$

$f_y = 555.56$

$s = 100.00$

V_{s1} is multiplied by $\text{Col1} = 1.00$

$s/d = 0.625$

$V_{s2} = 0.00$ is calculated for core, with:

$d = 80.00$

$A_v = 100530.965$

$f_y = 555.56$

$s = 250.00$

Vs2 is multiplied by Col2 = 0.00
s/d = 3.125
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 122116.319
bw = 200.00

End Of Calculation of Shear Capacity ratio for element: column JC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjrs

Constant Properties

Knowledge Factor, = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $f_c = f_{cm} = 33.00$
New material of Secondary Member: Steel Strength, $f_s = f_{sm} = 555.56$
Concrete Elasticity, $E_c = 26999.444$
Steel Elasticity, $E_s = 200000.00$
External Height, $H = 200.00$
External Width, $W = 200.00$
Internal Height, $H = 100.00$
Internal Width, $W = 100.00$
Cover Thickness, $c = 10.00$
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ($l_b/l_d >= 1$)
No FRP Wrapping

Stepwise Properties

Bending Moment, $M = -9.0143946E-008$
Shear Force, $V_2 = 37594.437$
Shear Force, $V_3 = -6.2539570E-011$
Axial Force, $F = -218084.658$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: $As_t = 0.00$
-Compression: $As_c = 3292.389$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten} = 983.3185$
-Compression: $As_{c,com} = 983.3185$
-Middle: $As_{mid} = 1325.752$
Longitudinal External Reinforcement Area Distribution (in 3 divisions)
-Tension: $As_{t,ten,jacket} = 829.3805$
-Compression: $As_{c,com,jacket} = 829.3805$
-Middle: $As_{mid,jacket} = 402.1239$
Longitudinal Internal Reinforcement Area Distribution (in 3 divisions)

-Tension: $Asl,ten,core = 153.938$
-Compression: $Asl,com,core = 153.938$
-Middle: $Asl,mid,core = 923.6282$

Mean Diameter of Tension Reinforcement, $DbL = 17.50$

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0^*$ $u = 0.07272853$
 $u = y + p = 0.07272853$

- Calculation of y -

$y = (My*Ls/3)/Eleff = 0.03857221$ ((4.29),Biskinis Phd))
 $My = 1.0143E+008$
 $Ls = M/V$ (with $Ls > 0.1*L$ and $Ls < 2*L$) = 1500.00
From table 10.5, ASCE 41_17: $Eleff = factor*Ec*Ig = 1.3147E+012$
 $factor = 0.36521565$
 $Ag = 40000.00$
Mean concrete strength: $fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00$
 $N = 218084.658$
 $Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 3.5999E+012$

Calculation of Yielding Moment My

Calculation of y and My according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1087819E-005$
with $fy = 555.56$
 $d = 172.00$
 $y = 0.48050392$
 $A = 0.1071203$
 $B = 0.06705607$
with $pt = 0.02858484$
 $pc = 0.02858484$
 $pv = 0.03853931$
 $N = 218084.658$
 $b = 200.00$
 $" = 0.1627907$
 $y_{comp} = 2.6249185E-005$
with $fc = 33.00$
 $Ec = 26999.444$
 $y = 0.48728983$
 $A = 0.08130094$
 $B = 0.05564476$
with $Es = 200000.00$

Calculation of ratio lb/d

Adequate Lap Length: $lb/d \geq 1$

- Calculation of p -

From table 10-8: $p = 0.03415631$

with:

- Columns not controlled by inadequate development or splicing along the clear height because $lb/d \geq 1$
shear control ratio $VyE/ColOE = 0.4563967$
 $d = d_{external} = 172.00$
 $s = s_{external} = 150.00$
 $t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00885929$
jacket: $s1 = Av1*h1/(s1*Ag) = 0.00785398$

$A_{v1} = 157.0796$, is the total area of all stirrups parallel to loading (shear) direction

$h1 = 200.00$

$s1 = 100.00$

core: $s2 = A_{v2} \cdot h2 / (s2 \cdot A_g) = 0.00100531$

$A_{v2} = 100.531$, is the total area of all stirrups parallel to loading (shear) direction

$h2 = 100.00$

$s2 = 250.00$

The term $2 \cdot t_f / b_w \cdot (f_{fe} / f_s)$ is implemented to account for FRP contribution

where $f = 2 \cdot t_f / b_w$ is FRP ratio (EC8 - 3, A.4.4.3(6)) and f_{fe} / f_s normalises f to steel strength

All these variables have already been given in Shear control ratio calculation.

For the normalisation f_s of jacket is used.

$NUD = 218084.658$

$A_g = 40000.00$

$f_{cE} = (f_{c_jacket} \cdot Area_jacket + f_{c_core} \cdot Area_core) / section_area = 33.00$

$f_{yE} = (f_{y_ext_Long_Reinf} \cdot Area_ext_Long_Reinf + f_{y_int_Long_Reinf} \cdot Area_int_Long_Reinf) / Area_Tot_Long_Rein = 555.56$

$f_{yE} = (f_{y_ext_Trans_Reinf} \cdot s1 + f_{y_int_Trans_Reinf} \cdot s2) / (s1 + s2) = 555.56$

$\rho_l = Area_Tot_Long_Rein / (b \cdot d) = 0.09570899$

$b = 200.00$

$d = 172.00$

$f_{cE} = 33.00$

End Of Calculation of Chord Rotation Capacity for element: column JC1 of floor 1

At local axis: 2

Integration Section: (b)

Calculation No. 15

column C1, Floor 1

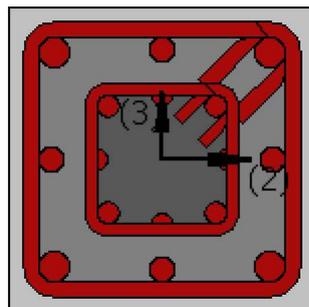
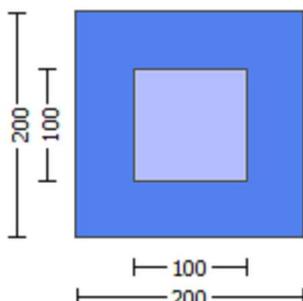
Limit State: Life Safety (data interpolation between analysis steps 50 and 51)

Analysis: Uniform +X

Check: Shear capacity V_{Rd}

Edge: End

Local Axis: (3)



```

Start Of Calculation of Shear Capacity for element: column JC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjrs

Constant Properties
-----
Knowledge Factor,   = 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, 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
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
#####
Note: Especially for the calculation of  $\gamma$  for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
#####
External Height, H = 200.00
External Width, W = 200.00
Internal Height, H = 100.00
Internal Width, W = 100.00
Cover Thickness, c = 10.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Adequate Lap Length ( $l_o/l_{o,u,min} = l_b/l_d \geq 1$ )
No FRP Wrapping
-----

Stepwise Properties
-----
EDGE -A-
Bending Moment, Ma = -9.9495397E-008
Shear Force, Va = 6.2539570E-011
EDGE -B-
Bending Moment, Mb = -9.0143946E-008
Shear Force, Vb = -6.2539570E-011
BOTH EDGES
Axial Force, F = -218084.658
Longitudinal Reinforcement Area Distribution (in 2 divisions)
-Tension: Aslt = 0.00
-Compression: Aslc = 3292.389
Longitudinal Reinforcement Area Distribution (in 3 divisions)
-Tension: Asl,ten = 983.3185
-Compression: Asl,com = 983.3185
-Middle: Asl,mid = 1325.752
Mean Diameter of Tension Reinforcement, DbL,ten = 17.50
-----
-----

```

New component: From table 7-7, ASCE 41_17: Final Shear Capacity $V_R = 1.0 \cdot V_n = 177628.325$
 V_n ((10.3), ASCE 41-17) = $k_n \cdot V_{Col} = 177628.325$
 $V_{Col} = 177628.325$
 $k_n = 1.00$
displacement_ductility_demand = 2.2204460E-016

NOTE: In expression (10-3) ' $V_s = A_v \cdot f_y \cdot d / s$ ' is replaced by ' $V_s + f \cdot V_f$ '
where V_f is the contribution of FRPs (11.3), ACI 440).

= 1 (normal-weight concrete)
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 25.00$, but $f_c'^{0.5} \leq 8.3$
MPa (22.5.3.1, ACI 318-14)
 $M/Vd = 2.00$
 $\mu_u = 9.0143946E-008$
 $V_u = 6.2539570E-011$
 $d = 0.8 \cdot h = 160.00$
 $N_u = 218084.658$
 $A_g = 40000.00$
From (11.5.4.8), ACI 318-14: $V_s = V_{s1} + V_{s2} = 125663.706$
where:
 $V_{s1} = 125663.706$ is calculated for jacket, with:
 $d = 160.00$
 $A_v = 157079.633$
 $f_y = 500.00$
 $s = 100.00$
 V_{s1} is multiplied by $Col1 = 1.00$
 $s/d = 0.625$
 $V_{s2} = 0.00$ is calculated for core, with:
 $d = 80.00$
 $A_v = 100530.965$
 $f_y = 500.00$
 $s = 250.00$
 V_{s2} is multiplied by $Col2 = 0.00$
 $s/d = 3.125$
 V_f ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: $V_s + V_f \leq 106288.613$
 $b_w = 200.00$

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 = 4.2143303E-018
 $y = (M_y \cdot L_s / 3) / E_{eff} = 0.03857221$ ((4.29), Biskinis Phd)
 $M_y = 1.0143E+008$
 $L_s = M/V$ (with $L_s > 0.1 \cdot L$ and $L_s < 2 \cdot L$) = 1500.00
From table 10.5, ASCE 41_17: $E_{eff} = factor \cdot E_c \cdot I_g = 1.3147E+012$
factor = 0.36521565
 $A_g = 40000.00$
Mean concrete strength: $f_c' = (f_c'_{jacket} \cdot Area_{jacket} + f_c'_{core} \cdot Area_{core}) / Area_{section} = 33.00$
 $N = 218084.658$
 $E_c \cdot I_g = E_c \cdot I_{g,jacket} + E_c \cdot I_{g,core} = 3.5999E+012$

Calculation of Yielding Moment M_y

Calculation of δ / y and M_y according to Annex 7 -

$y = \text{Min}(y_{ten}, y_{com})$
 $y_{ten} = 3.1087819E-005$
with $f_y = 555.56$

d = 172.00
y = 0.48050392
A = 0.1071203
B = 0.06705607
with pt = 0.02858484
pc = 0.02858484
pv = 0.03853931
N = 218084.658
b = 200.00
" = 0.1627907
y_comp = 2.6249185E-005
with fc = 33.00
Ec = 26999.444
y = 0.48728983
A = 0.08130094
B = 0.05564476
with Es = 200000.00

Calculation of ratio l_b/l_d

Adequate Lap Length: $l_b/l_d \geq 1$

End Of Calculation of Shear Capacity for element: column JC1 of floor 1

At local axis: 3

Integration Section: (b)
